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**SOUND PERFORMANCE OF
WOOD FLOOR/CEILING
ASSEMBLIES
(STAGE II)**

Report No. 89-114

SOUND PERFORMANCE OF WOOD FLOOR/CEILING ASSEMBLIES (STAGE II)

A Study Made for

CANADA MORTGAGE AND HOUSING CORPORATION
682 Montreal Road,
Ottawa, Ontario.

(Attention: Jacques Rousseau, Project Manager)

by

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July 10, 1990.

EXECUTIVE SUMMARY

SOUND PERFORMANCE OF WOOD FLOOR/CEILING ASSEMBLIES (STAGE II)

INTRODUCTION

In response to concerns re excessive noise transmission between units in group housing projects, Canada Mortgage and Housing Corporation has commissioned studies of the performance of floor/ceiling assemblies separating superimposed units in wood framed buildings.

Stage I examined ceiling assemblies and absorptive materials in the joist cavity, (report by MJM Acoustical Consultants Inc., February 15, 1989). The tests of Stage I indicated that to maximize the acoustical isolation, it is necessary to:

1. Maximize the mass of the gypsum board ceiling;
2. Suspend the ceiling on resilient furring;
3. Provide absorbing material in the joist cavity, (possibly filling the cavity).

This report, (Stage II), focuses on the performance of various floor treatments. Tests were conducted on 22 assemblies. The testing was done at the National Research Council of Canada.

OBJECTIVES

It is our opinion that, if any floor/ceiling structure is to be seen to be acceptable by architects and builders, then:

1. the cost must be reasonable;
2. any difference in elevation where a floor surface type changes, (e.g. carpet to ceramic tile), must be minimal, (say 20 mm maximum);
3. the sound and impact isolation, must meet the expectations of the vast majority of the occupants, (say STC 55 and IIC 55).

Eleven of the assemblies met these objectives, (floors, 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21).

SUMMARY & CONCLUSIONS

1. Table ES-1 and fig. ES-1 summarize the construction and results.
2. Floor 3 was selected as the basic floor/ceiling because of its:
 - (a) slightly better impact isolation
 - (b) superior thermal insulation.
3. The airborne sound insulation increases with floor surface mass, at about 6 dB per double surface mass, (see fig. ES-2).
4. The impact sound isolation cannot be related to the surface mass, (see fig. ES-3).
5. Carpet with a separate foam underpad provides excellent impact isolation. If an additional mass of about 10 kg/m^2 is inserted between the carpet and the basic floor/ceiling, STC 60 and IIC 60 will be achieved.

6. An additional layer of plywood attached to the basic floor/ceiling increases the STC due to the added mass. It also increases the high frequency IIC, probably due to the additional internal damping. Providing building paper between the plywood layers is not effective.
7. When a layer of fibre board was inserted between the plywood layers, the STC increased, (due to the added mass), and the IIC increased, (probably mainly due to the fact that the fibre board was floating on the basic floor/ceiling).
8. A 19 mm concrete layer was used in several tests. This was a laminate of two layers of 6 mm prefabricated concrete board, (Wonderboard), cemented together with a 6 mm cement slurry mortar.

This concrete layer served two purposes:

- (i) it allowed the evaluation of the effect of significant added mass;
 - (ii) it simulated a hard finish floor surfaced, (marble, ceramic tile, etc.).
9. When the finish floor is not carpet, it is necessary to provide a floating floor to achieve high impact isolation, (IIC 55 and up).
 10. Furred floating floors are acoustically the same as similar unfurred floating floors. We therefore prefer the unfurred floors for their reduced thickness.

11. Suggested construction:

(i) Carpet: see paragraph 5 above.

(ii) Hardwood, vinyl, etc: on floors 19 or 20.

(iii) Marble, ceramic tile, etc: on floors 19, 20, 9, 17, or 18.

12. During construction, great care must be taken to insure that resilient layers are not short-circuited, (with nails, screws, concrete, etc.). This applies at both the ceiling and the floor. Perimeter details must allow movement, yet be airtight.

TABLE ES-1

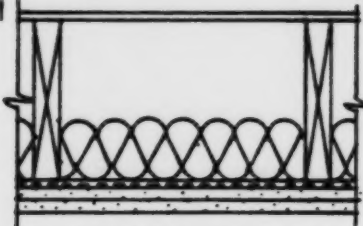
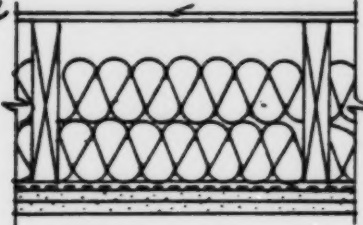
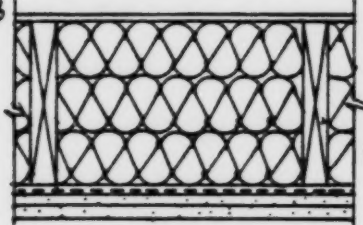
Floor no.	Height above BASIC floor/ ceiling.	STC IIC
1	 16 mm PLYWOOD 38 x 230 mm JOISTS AT 400 mm CENTRES 13 mm RESILIENT FURRING AT 600 mm CENTRES 2 x 16 mm GYPSUM BOARD 1 LAYER 90 mm GLASS FIBRE BATT INSULATION	52 48
2	 SAHE AS FLOOR 1, EXCEPT 2 LAYERS OF 90 mm GLASS FIBRE BATTS	52 48
3	 SAHE AS FLOOR 1, EXCEPT 3 LAYERS OF 90 mm GLASS FIBRE BATTS. THIS IS THE BASIC FLOOR/ CEILING THAT FORMS PART OF FLOORS 4 THROUGH 22	51 49
4	 10 mm CARPET BASIC FLOOR / CEILING	54 63
5	 CARPET WITH INTEGRAL FOAM BACKING (5 mm PILE, 5 mm FOAM) BASIC FLOOR / CEILING	55 65

TABLE ES-1 (cont'd)

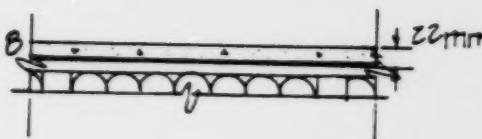
Floor no.	Height above BASIC floor/ ceiling	STC IIC
6	 16mm 10 mm CARPET 6 mm FELT UNDERPAD BASIC FLOOR/CEILING	56 69
7	 20mm 10 mm CARPET 9 mm FOAM UNDERPAD BASIC FLOOR/CEILING	55 81
8	 22mm 19 mm CONCRETE 3 mm FOAM RUBBER BASIC FLOOR/CEILING	62 56
9	 29mm 19 mm CONCRETE 9 mm FOAM UNDERPAD BASIC FLOOR/CEILING	62 59
10	 38mm 19 mm CONCRETE 16 x 70 mm WOOD FURRING AT 400 mm CENTRES 3 x 70 mm FOAM RUBBER UNDER FURRING BASIC FLOOR/CEILING	61 57

TABLE ES-1 (cont'd)

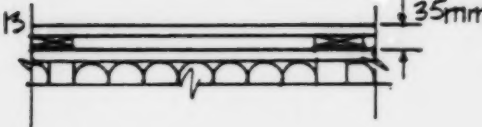
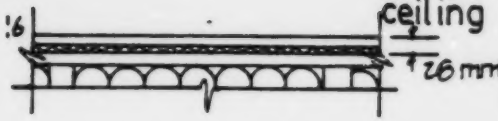
Floor no.	Height above BASIC floor/ ceiling	STC IIC
11	 38mm SAME AS FLOOR 10, EXCEPT FIBRE GLASS BETWEEN FURRING STRIPS	62 59
12	 16mm 16 mm PLYWOOD BASIC FLOOR/CEILING	58 53
13	 35mm 16 mm PLYWOOD 16 x 70 mm FURRING AT 100 mm CENTRES 3 x 70 mm FOAM RUBBER UNDER FURRING BASIC FLOOR/CEILING	58 54
14	 35mm SAME AS FLOOR 13, EXCEPT FIBRE GLASS BETWEEN FURRING STRIPS	60 57
15	 17mm 16 mm PLYWOOD 1 mm BUILDING PAPER BASIC FLOOR/CEILING	58 52

TABLE ES -1 (cont'd)

Floor no.	Height above BASIC floor/ ceiling	STC	IIC
16	 16 mm PLYWOOD 12 mm FIBRE BOARD BASIC FLOOR/CEILING	61	57
17	 19 mm CONCRETE 2 mm GEOTEXTILE BASIC FLOOR/CEILING	62	58
18	 19 mm CONCRETE 6 mm FELT UNDERPAD BASIC FLOOR/CEILING	63	59
19	 19 mm PLYWOOD 6 mm FELT UNDERPAD BASIC FLOOR/CEILING	60	56
20	 19 mm PLYWOOD 2 mm GEOTEXTILE BASIC FLOOR/CEILING	60	55

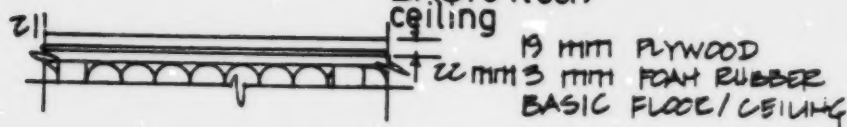
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TABLE ES-1 (cont'd)

Floor no.

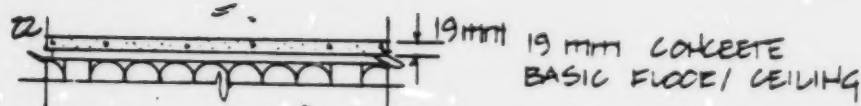
Height above
BASIC floor/
ceiling

STC IIC



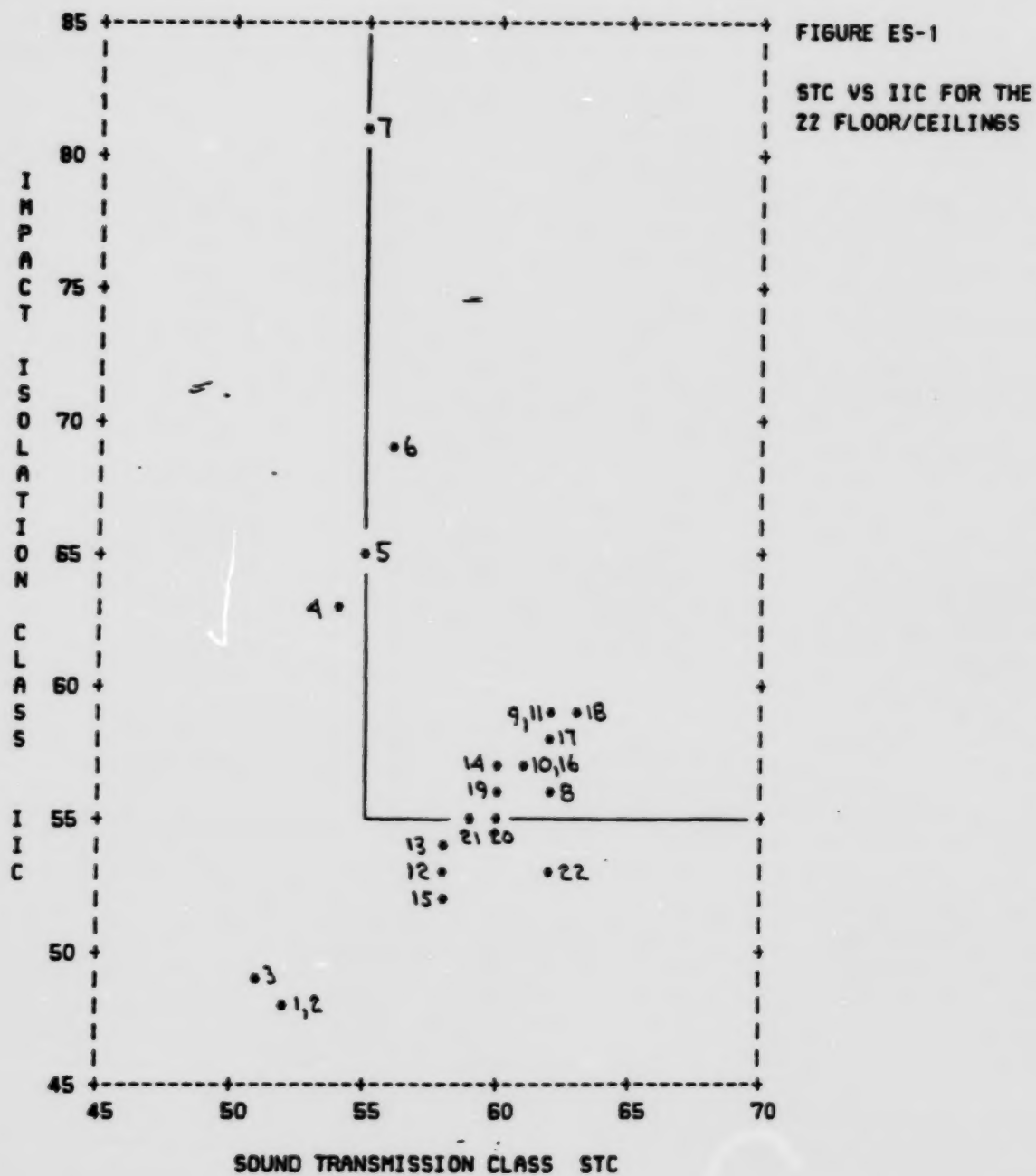
19 mm PLYWOOD
3 mm FOAM RUBBER
BASIC FLOOR/CEILING

59 55

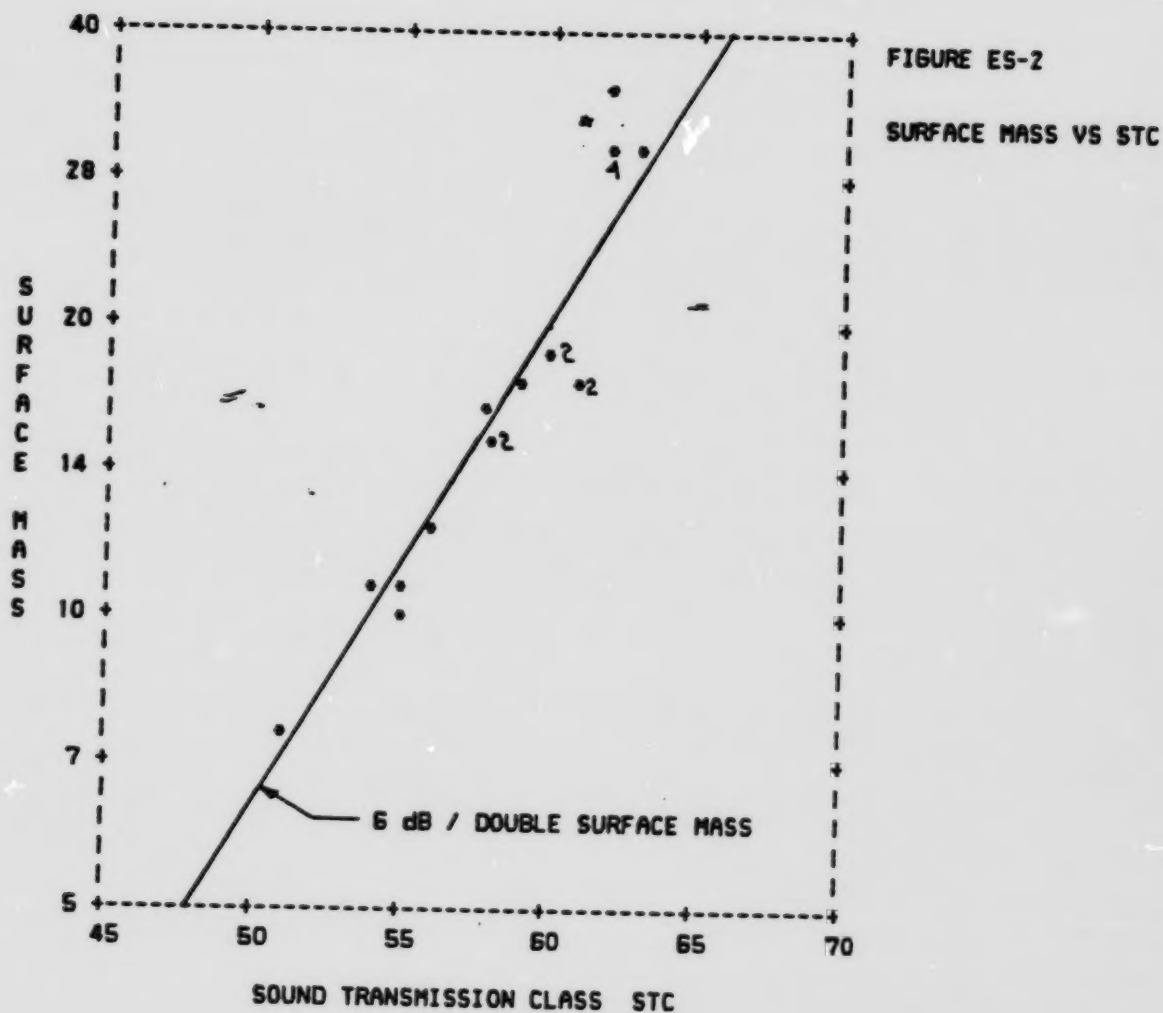


19 mm CONCRETE
BASIC FLOOR/CEILING

62 53

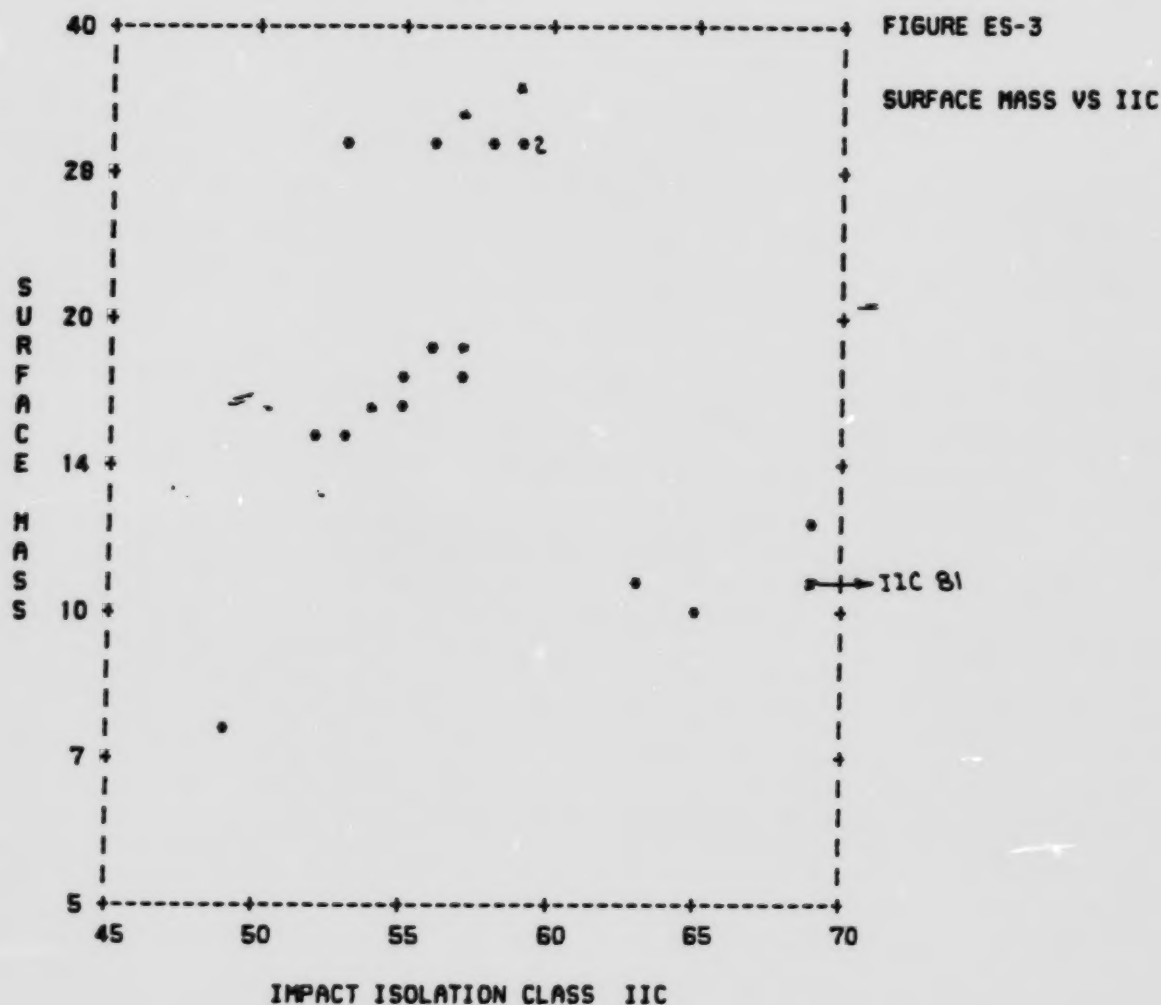


OBSERVE THAT 14 OF THE FLOOR/CEILINGS MEET BOTH STC 55 AND IIC 55



NOTE: 1. THE SURFACE MASS, (kg/m^2), INCLUDES THE 16mm PLYWOOD TOP SURFACE OF THE BASIC FLOOR AND THE COMPONENT(S) ABOVE IT.

2. WHERE A NUMBER IS SHOWN ADJACENT TO A DATA POINT, IT INDICATES THE NUMBER OF FLOORS THAT COINCIDE AT THAT POINT.



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2. WHERE A NUMBER IS SHOWN ADJACENT TO A DATA POINT, IT INDICATES THE NUMBER OF FLOORS THAT COINCIDE AT THAT POINT.

REPORTSOUND PERFORMANCE OF WOOD FLOOR/CEILING ASSEMBLIES (STAGE II)INTRODUCTION

In response to concerns re excessive noise transmission between units in group housing projects, Canada Mortgage and Housing Corporation has commissioned studies of the performance of floor/ceiling assemblies separating superimposed units in wood framed buildings.

Stage I examined ceiling assemblies and absorptive materials in the joist cavity, (report by MJM Acoustical Consultants Inc., February 15, 1989). The tests of Stage I indicated that to maximize the acoustical isolation, it is necessary to:

1. maximize the mass of the gypsum board ceiling;
2. suspend the ceiling on resilient furring;
3. provide absorbing material in the joist cavity, (possibly filling the cavity).

This report, (Stage II), focuses on the performance of various floor treatments. Tests were conducted on 22 assemblies. The testing was done at the National Research Council of Canada under the supervision of Dr. A. C. C. Warnock. The NRC report is appended to this report.

OBJECTIVES

It is our opinion that, if any floor/ceiling structure is to be seen to be acceptable by architects and builders, then:

1. the cost must be reasonable;
2. any difference in elevation where a floor surface type changes, (e.g. carpet to ceramic tile), must be minimal, (say 20 mm maximum);
3. the sound and impact isolation, must meet the expectations of the vast majority of the occupants, (say STC 55 and IIC 55).

Eleven of the assemblies met these objectives, (floors, 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21).

BASIC FLOOR/CEILING Figures 1 & 2

The base floor/ceiling was:

- 16 mm plywood
- 38 x 235 mm wood joists at 400 mm centres
- 13 mm resilient metal furring at 600 mm centres
- 2 layers of 16 mm gypsum board.

Floors 1, 2, and 3 were the base floor/ceiling with one, two and three layers respectively, of 90 mm (R-12) fiberglass batts in the cavity. As can be seen from figures 1 & 2, there is not much difference in their acoustical performances.

Floor 3 was selected as the Basic Floor/Ceiling because:

1. it has slightly better impact isolation at low frequencies;
2. it is probably desirable for its superior thermal insulation.

All of the rest of the floors consisted of the Basic Floor/Ceiling, (Floor 3), with various additions on top.

CARPET Figures 3 & 4

Figures 3 and 4 show the test results for four carpeted floors. From figure 4, we conclude that carpet on a separate foam underpad is best. Note that all of the IIC ratings are determined by the 8 dB rule at 100 Hz.

PLYWOOD: PLYWOOD ON BUILDING PAPER Figures 5 & 6

Figures 5 and 6 show that adding a second layer of plywood increases the transmission loss significantly at all frequencies, and also increases the high frequency impact loss.

It is also seen that placing a layer of building paper between the plywood layers has no significant effect.

PLYWOOD: PLYWOOD ON FIBRE BOARD Figures 7 & 8

Figures 7 and 8 show the effect of placing a layer of fibre board between two plywood layers. The transmission loss is improved at high frequencies. We attribute this to the increased mass, the impedance mismatch between plywood and fibreboard, and the lack of screw attachment to the basic floor/ceiling when the fibre board was incorporated.

CONCRETE: PLYWOOD Figures 9 & 10

Figures 9 and 10 compare a layer of concrete and of plywood, both screwed to the basic floor/ceiling. It is seen that concrete provides a better transmission loss, (due to greater mass).

The impact results show that concrete is better at low frequencies, and that plywood is better at high frequencies. We attribute this to the frequency distribution of the energy imparted by the tapping machine, (the harder concrete creates more high frequency vibration), and to the relatively high internal damping in plywood, (about twice that of concrete).

FLOATING FURRED FLOORS Figures 11 to 16

Four floating furred floors were tested, (floors 10, 11, 13, and 14).

Figures 11 and 12 compare a plywood floor with and without absorption between the furring strips. It is seen that the absorption is effective.

Figures 13 and 14 compare a concrete floor with and without absorption between the furring strips. It is seen that the absorption is effective in reducing impact noise.

Figures 15 and 16 compare the furred plywood floor with the furred concrete floor, (both with absorption between the furring strips). It is seen that the concrete floor is better at low frequencies, and that there is not much difference at high frequencies.

FLOATING FLOORS Figures 17 to 26

Seven floating floors were tested, (floors 8, 9, 17, 18, 19, 20, and 21).

Figures 17 and 18 compare a plywood floor floating on three different resilient materials. It is seen that the performance is essentially the same for each material.

Figures 19 and 20 compare a floating plywood floor with a screw attached plywood floor. It is seen that the floating floor is slightly better. (Note: the floating floor weighs about 2 kg/m^2 more than the screw attached floor.)

Figures 21 and 22 compare a concrete floor floating on four different resilient materials. It is seen that the transmission loss is essentially the same for each configuration, and that with the exception of the 3 mm foam rubber, the impact isolation is essentially the same.

Figures 23 and 24 compare a floating concrete floor with a screw attached concrete floor. The transmission losses are essentially identical. The floating floor provides much better impact isolation.

Figures 25 and 26 compare floating plywood and floating concrete. It is seen that the concrete floor provides better transmission loss, especially at low frequencies: Note that the mass of the concrete floor is 1.8 times that of the plywood floor, (these masses include the resilient layer and the 16 mm plywood top surface of the basic floor/ceiling). The impact measurements show that the concrete floor is better when averaged, although the plywood floor is better at high frequencies, (see the comment above re figure 10).

SUMMARY AND CONCLUSIONS

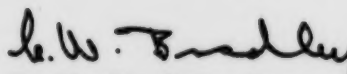
1. Twenty-two floor/ceilings were tested. Table ES-1 and fig. ES-1, (both in the executive summary), summarize the constructions and results.
2. Floor 3 was selected as the basic floor/ceiling because of its:
 - (a) slightly better impact isolation
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3. The airborne sound insulation increases with floor surface mass, at about 6 dB per double surface mass, (see fig. ES-2).
4. The impact sound isolation cannot be related to the surface mass, (see fig. ES-3).
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7. When a layer of fibre board was inserted between the plywood layers, the STC increased, (due to the added mass), and the IIC increased, (probably mainly due to the fact that the fibre board was floating on the basic floor/ceiling).

8. A 19 mm concrete layer was used in several tests. This was a laminate of two layers of 6 mm prefabricated concrete board, (Wonderboard), cemented together with a 6 mm cement slurry mortar. (It was necessary to load this assembly with weights, (concrete blocks), during the setting process.)

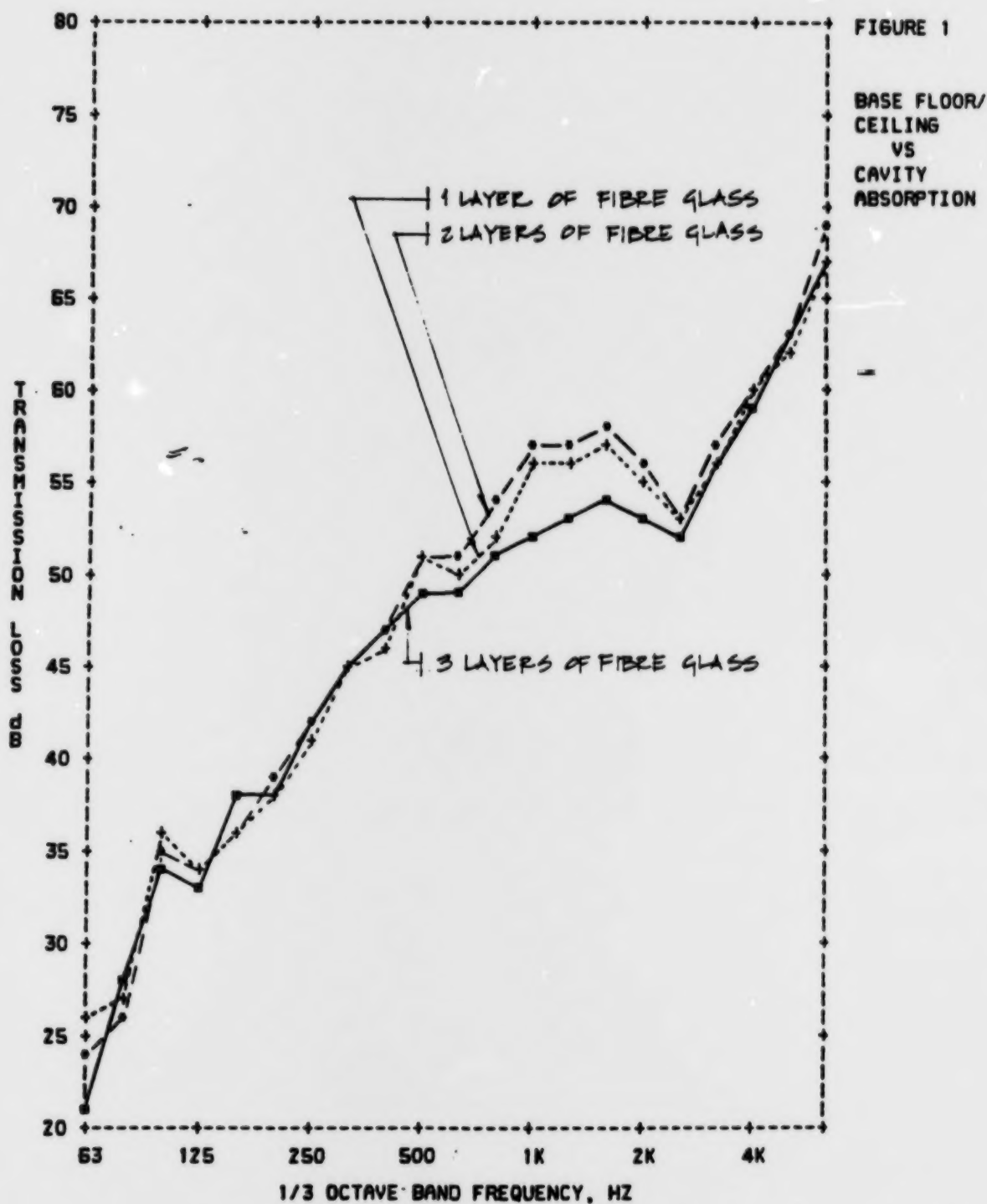
This concrete layer served two purposes:

- (i) it allowed the evaluation of the effect of significant added mass;
 - (ii) it simulated a hard finish floor surface, (marble, ceramic tile, etc.).
9. When the finish floor is not carpet, it is necessary to provide a floating floor to achieve high impact isolation, (IIC 55 and up).
10. A comparison of floor 11 with 17, and of floor 14 with 20, shows that furred floating floors are acoustically the same as similar unfurred floating floors. We therefore prefer the unfurred floors for their reduced thickness.
11. Suggested constructions.
- (i) Carpet: see paragraph 5 above.
 - (ii) Hardwood, vinyl, etc: on floors 19 or 20
 - (iii) Marble, ceramic tile, etc: on floors 19, 20, 9, 17 or 18.
12. During construction, great care must be taken to insure that resilient layers are not short-circuited, (with nails, screws, concrete, etc.). This applies at both the ceiling and the floor. Perimeter details must allow movement, yet be airtight.

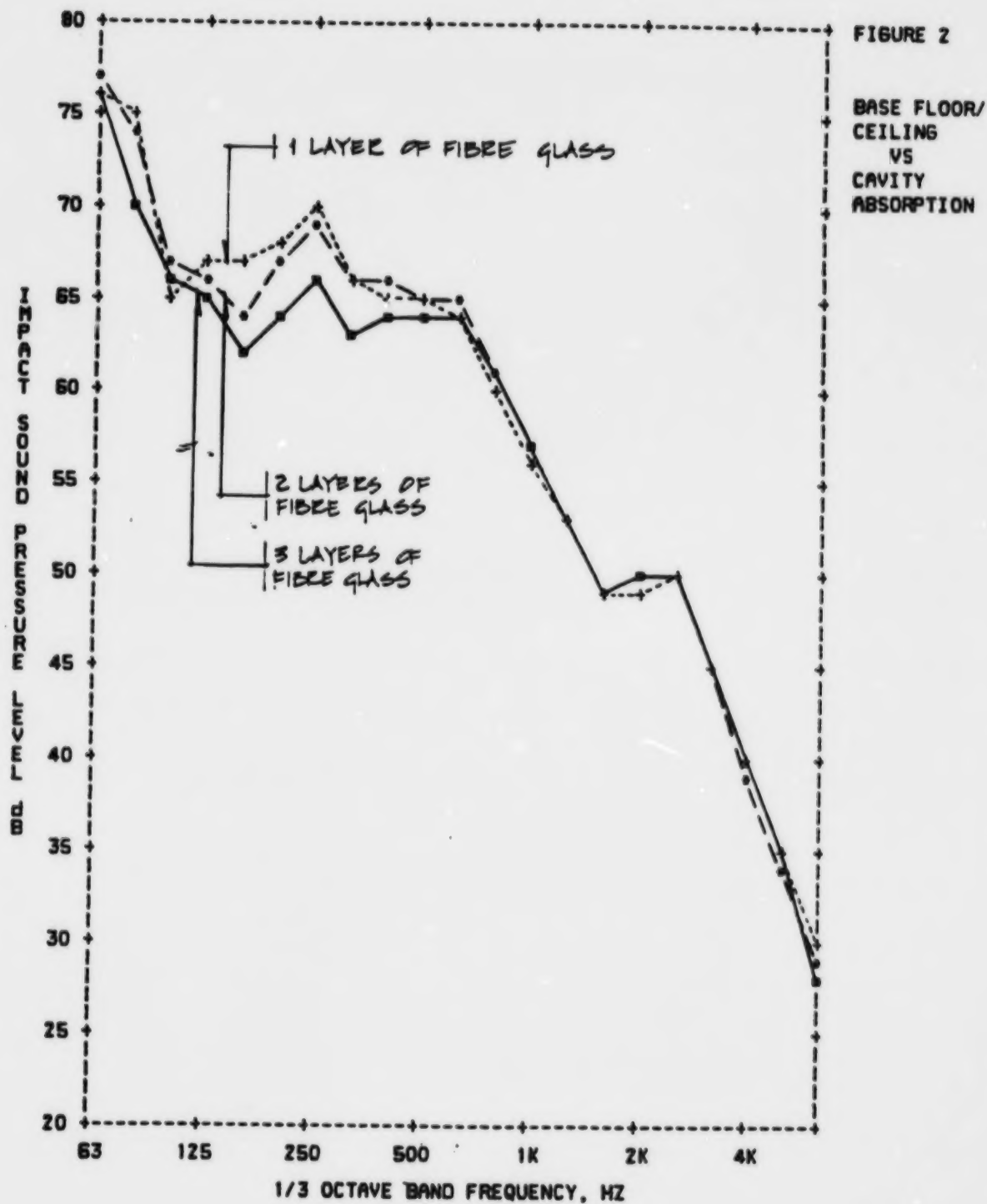
CWB:JF


C. W. Bradley, Eng.

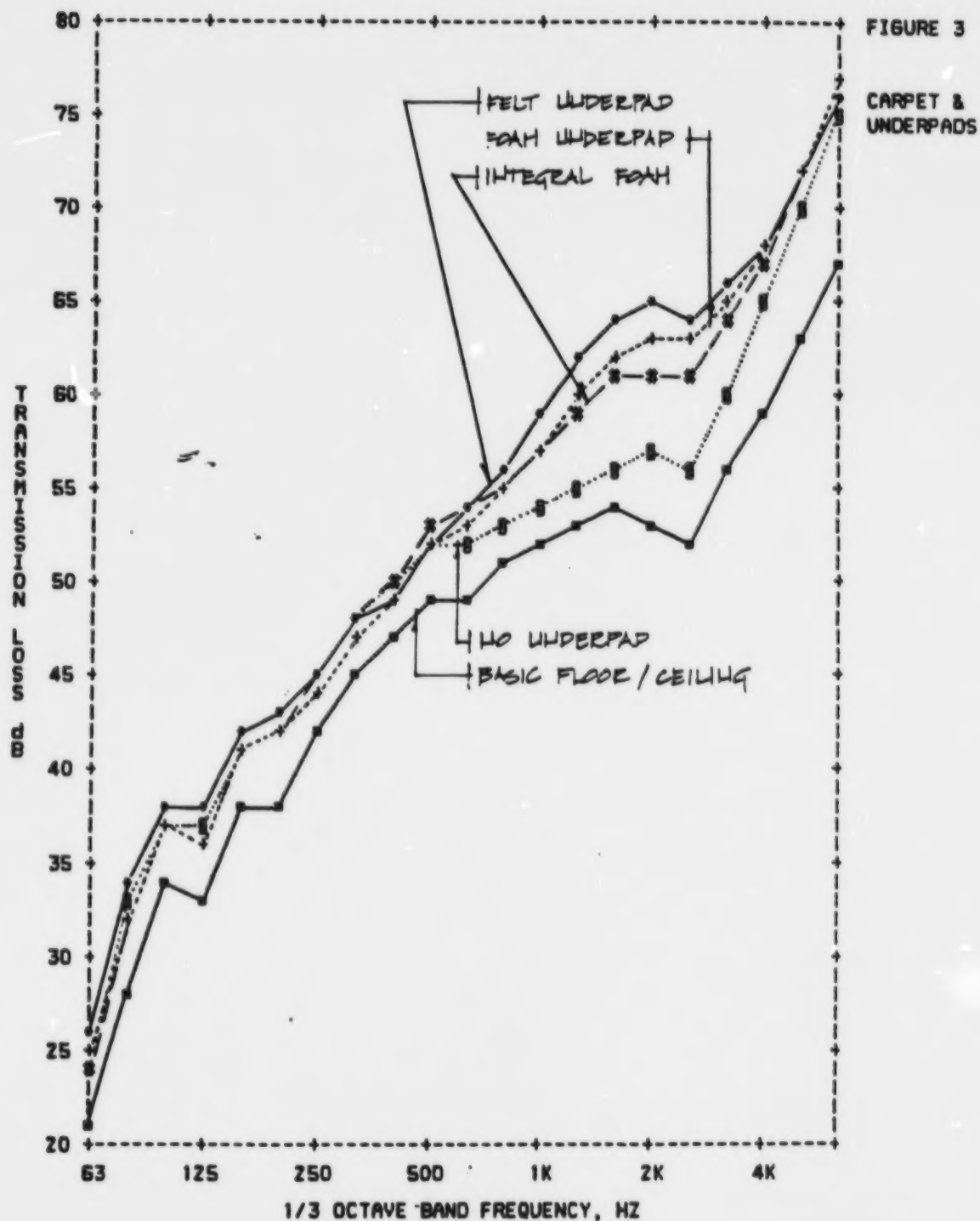
July 10, 1990.



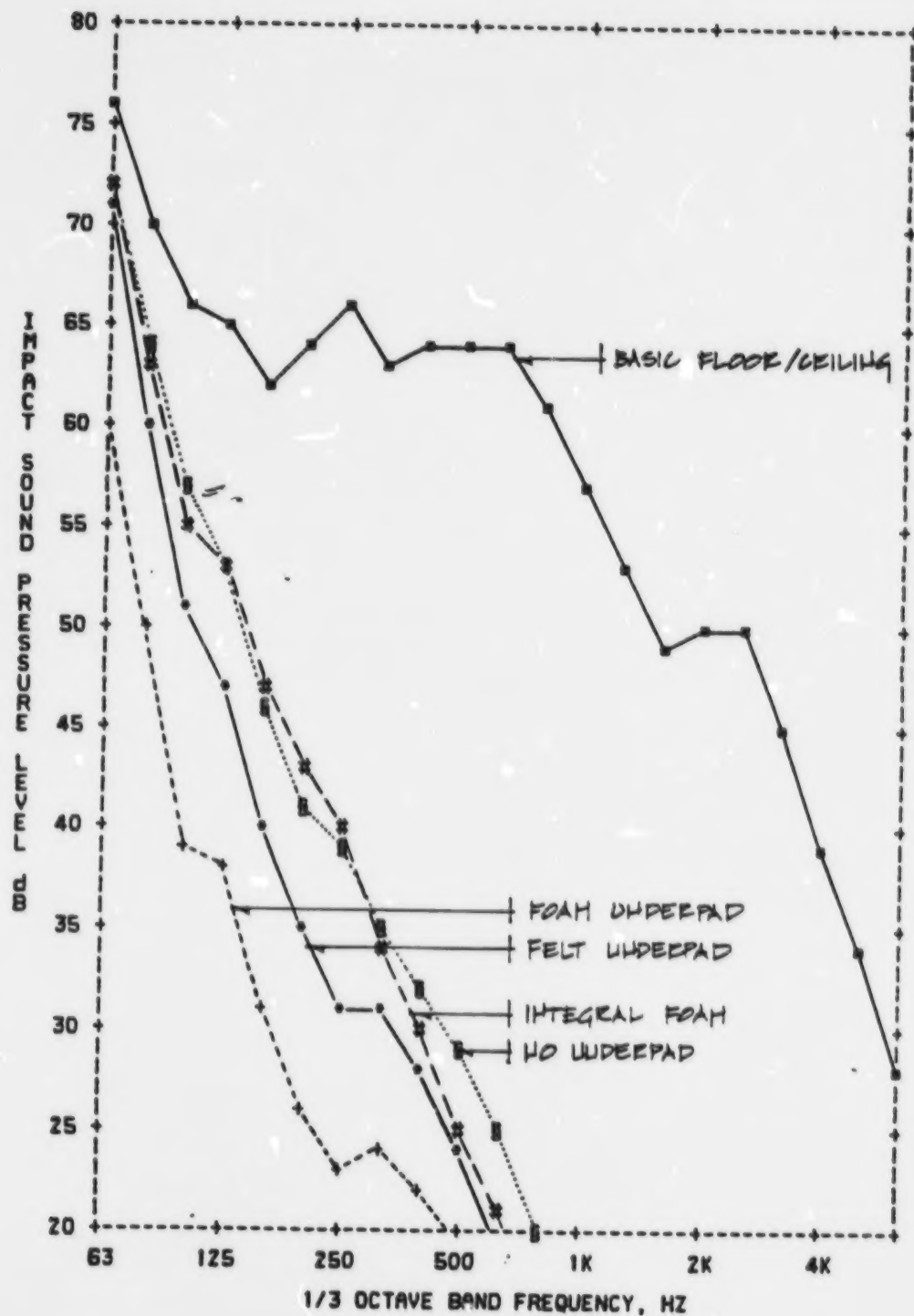
- + FLOOR 1 STC 52 BASE FLOOR/CEILING: 1 LAYER OF 90mm GLASS FIBRE IN CAVITY
- o FLOOR 2 STC 52 BASE FLOOR/CEILING: 2 LAYERS OF 90mm GLASS FIBRE IN CAVITY
- FLOOR 3 STC 51 BASE FLOOR/CEILING: 3 LAYERS OF 90mm GLASS FIBRE IN CAVITY



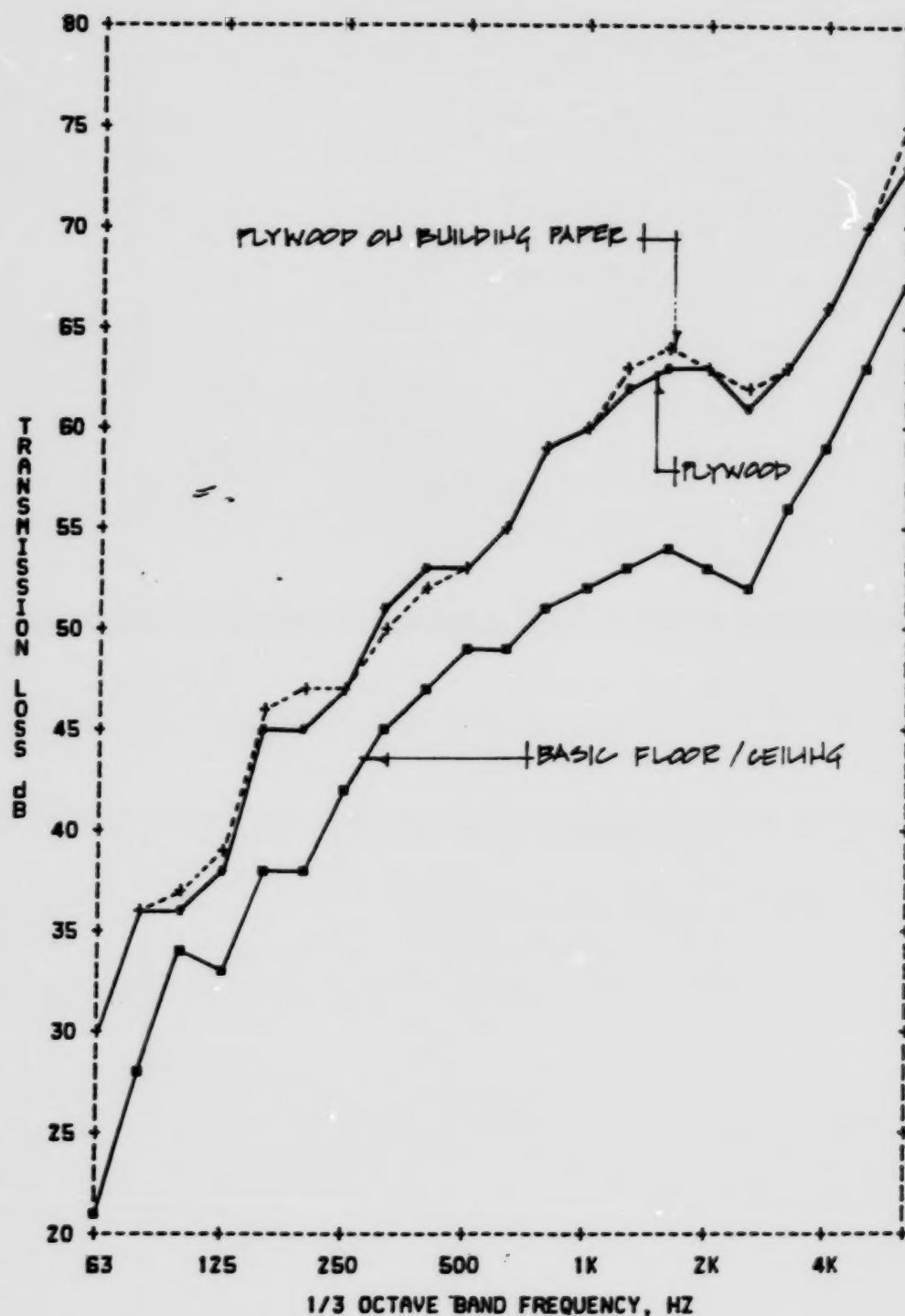
- + FLOOR 1 IIC 48 BASE FLOOR/CEILING: 1 LAYER OF 90MM GLASS FIBRE IN CAVITY
- FLOOR 2 IIC 48 BASE FLOOR/CEILING: 2 LAYERS OF 90MM GLASS FIBRE IN CAVITY
- FLOOR 3 IIC 49 BASE FLOOR/CEILING: 3 LAYERS OF 90MM GLASS FIBRE IN CAVITY



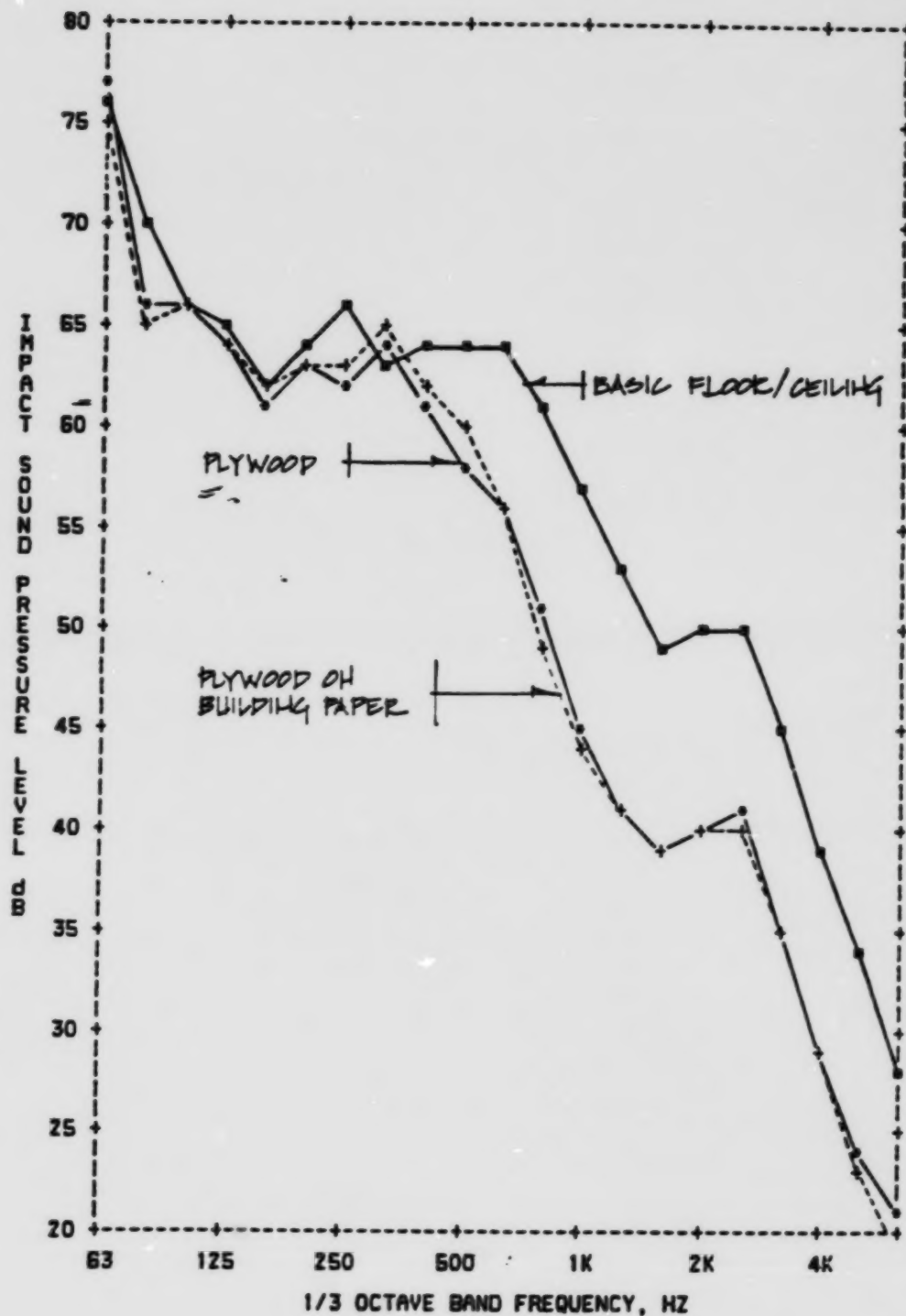
- FLOOR 4 STC 54 CARPET
- * FLOOR 5 STC 55 CARPET WITH INTEGRAL FOAM BACKING
- FLOOR 6 STC 56 CARPET ON 8mm FELT UNDERPAD
- + FLOOR 7 STC 55 CARPET ON 9mm OPEN CELL FOAM CARPET UNDERPAD
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



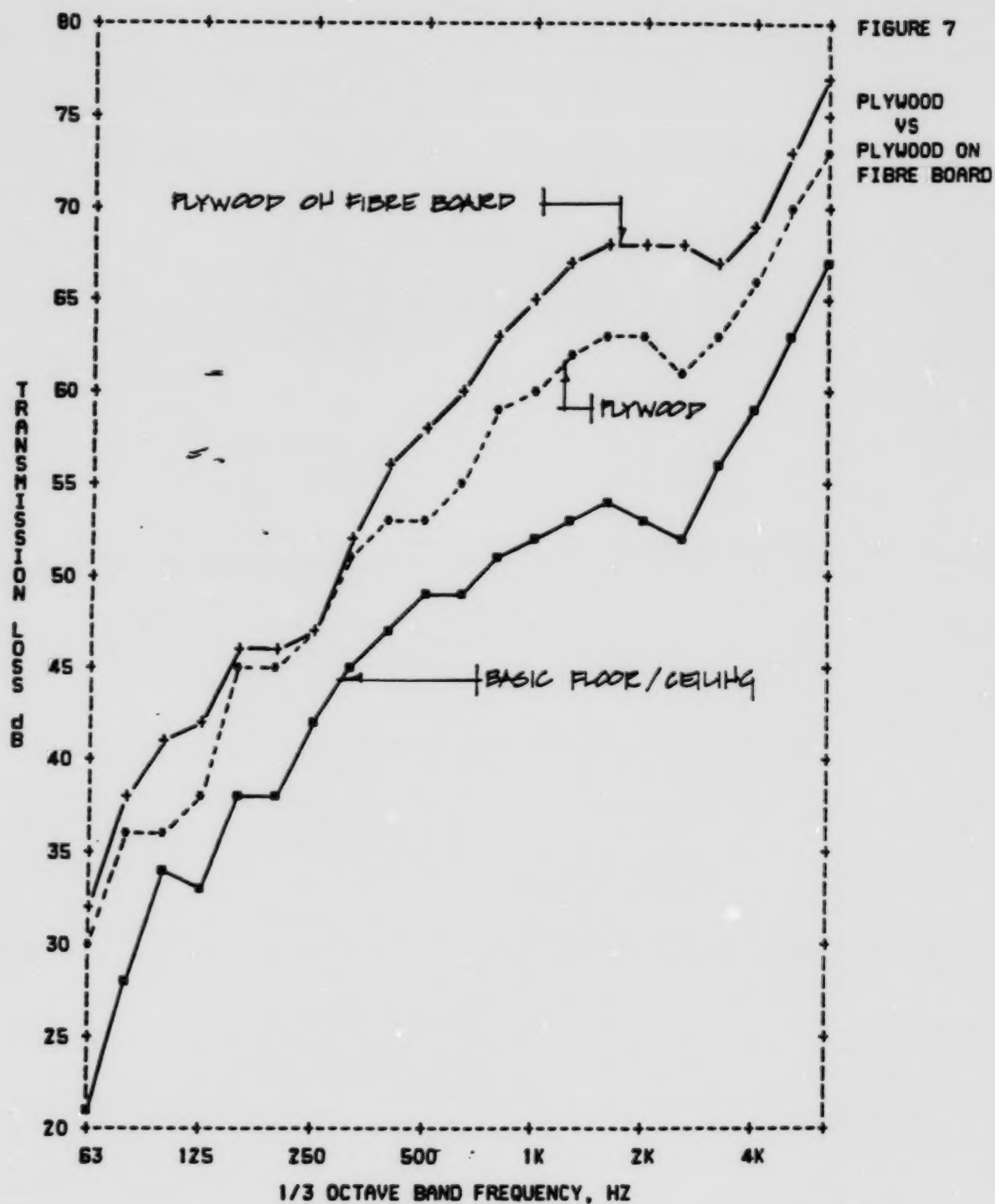
- FLOOR 4 IIC 63 CARPET
- * FLOOR 5 IIC 65 CARPET WITH INTEGRAL FOAM BACKING
- FLOOR 6 IIC 65 CARPET ON 6mm FELT UNDERPAD
- + FLOOR 7 IIC 81 CARPET ON 9mm OPEN CELL FOAM CARPET UNDERPAD
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



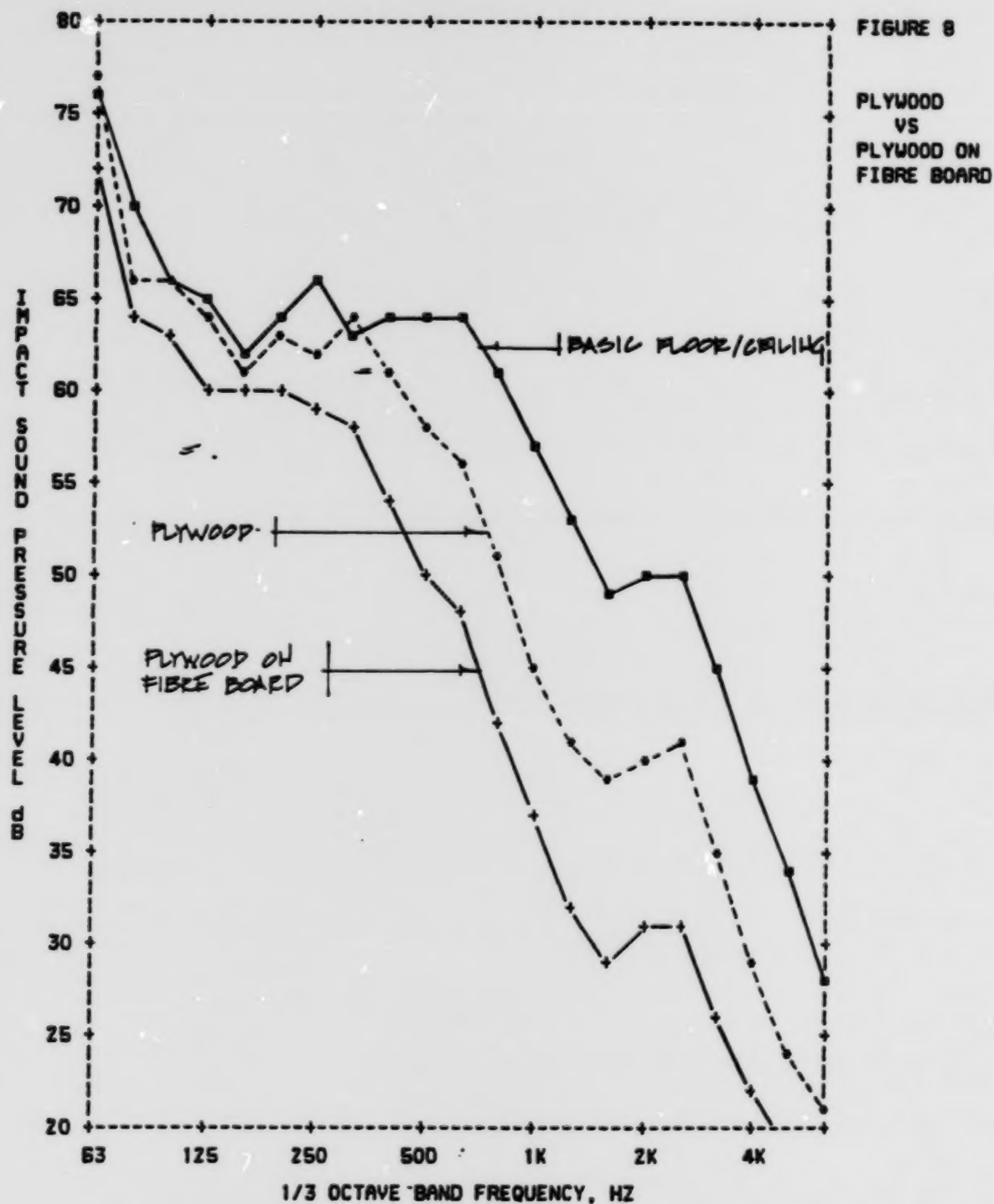
- FLOOR 12 STC 58 16mm PLYWOOD
- + FLOOR 15 STC 58 16mm PLYWOOD ON 1mm SATURATED BUILDING PAPER
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



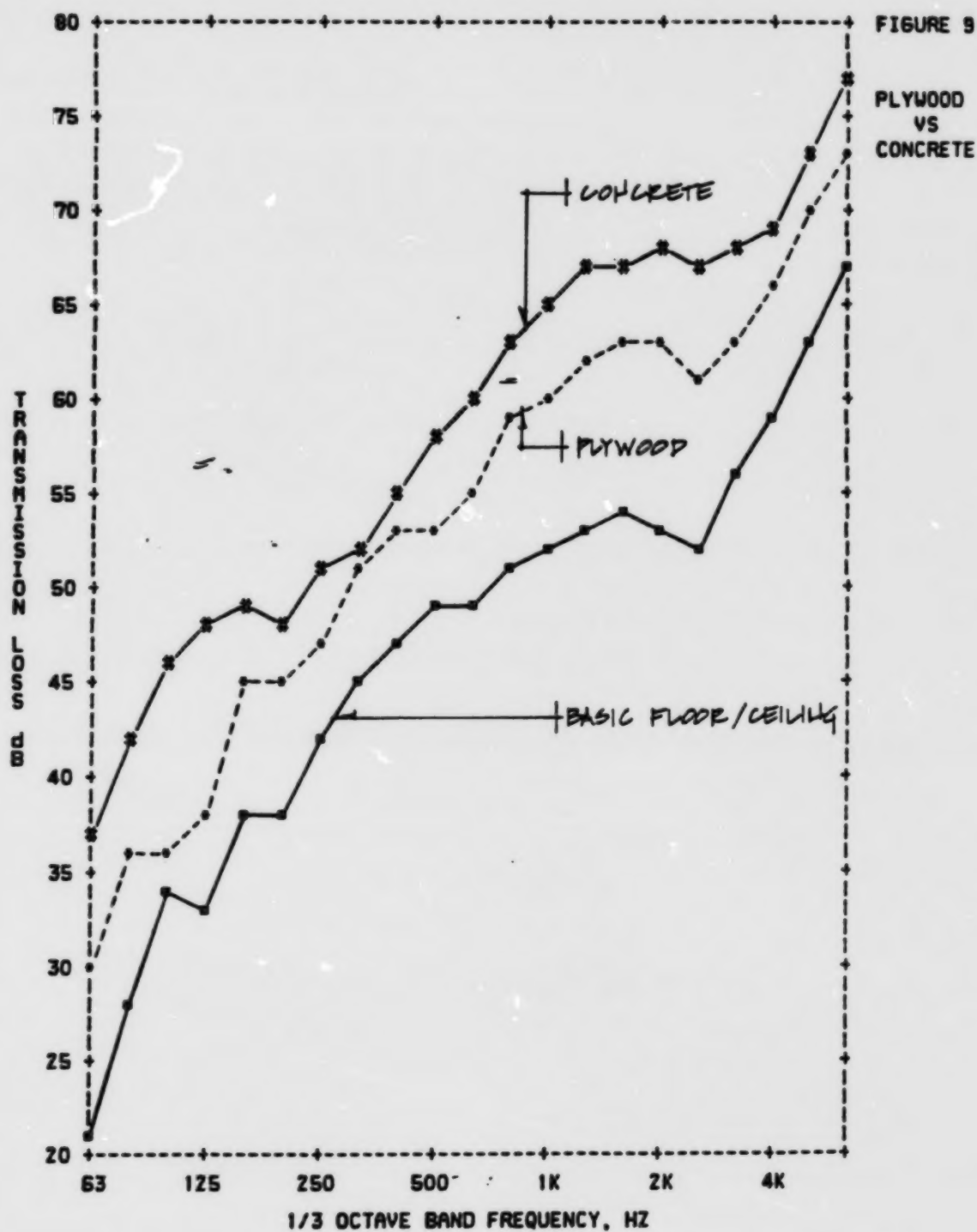
- FLOOR 12 IIC 53 16MM PLYWOOD
- + FLOOR 15 IIC 52 16MM PLYWOOD ON 1MM SATURATED BUILDING PAPER
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



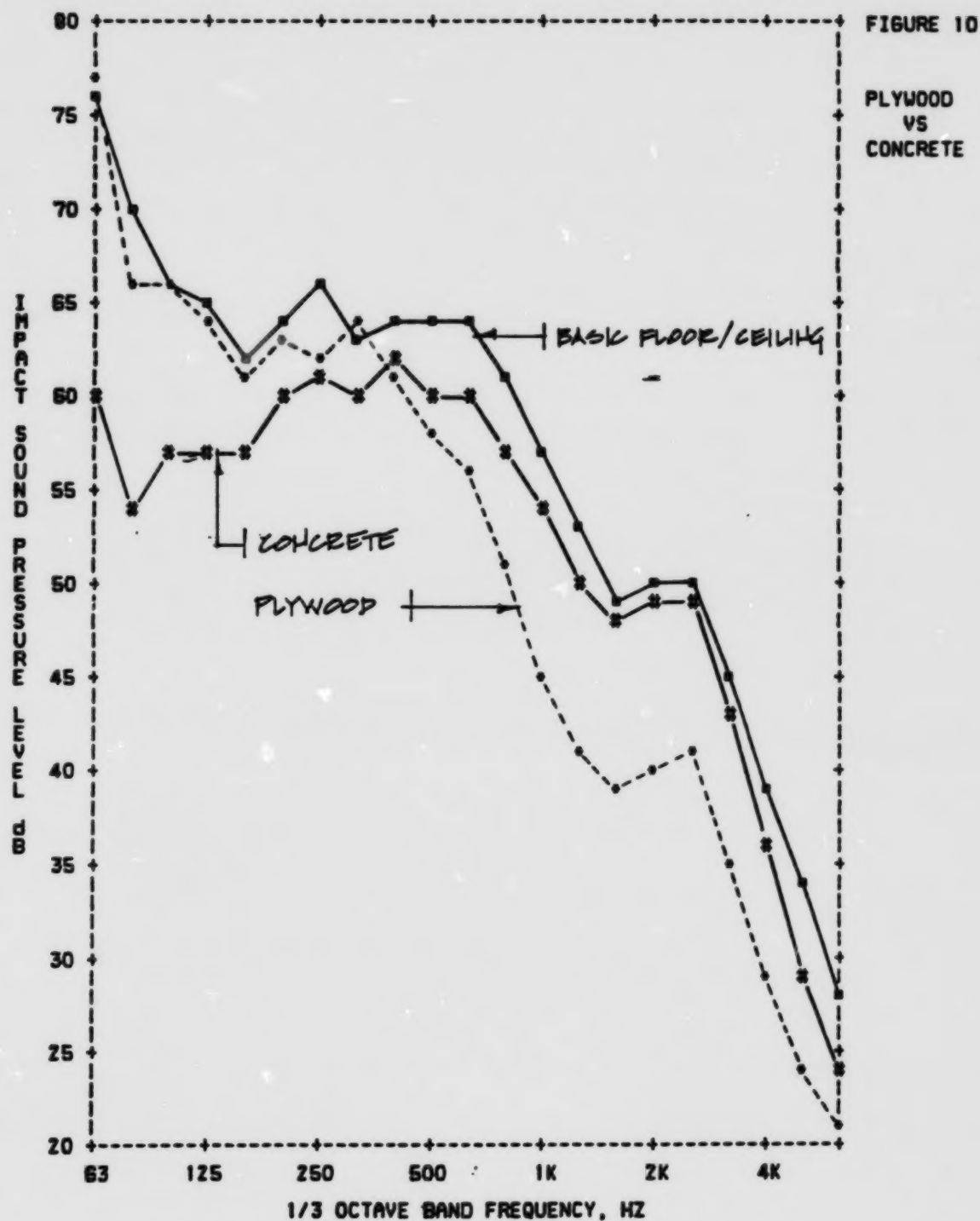
- FLOOR 12 STC 58 16mm PLYWOOD
- + FLOOR 16 STC 61 16mm PLYWOOD ON 11mm WOOD FIBRE BOARD
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



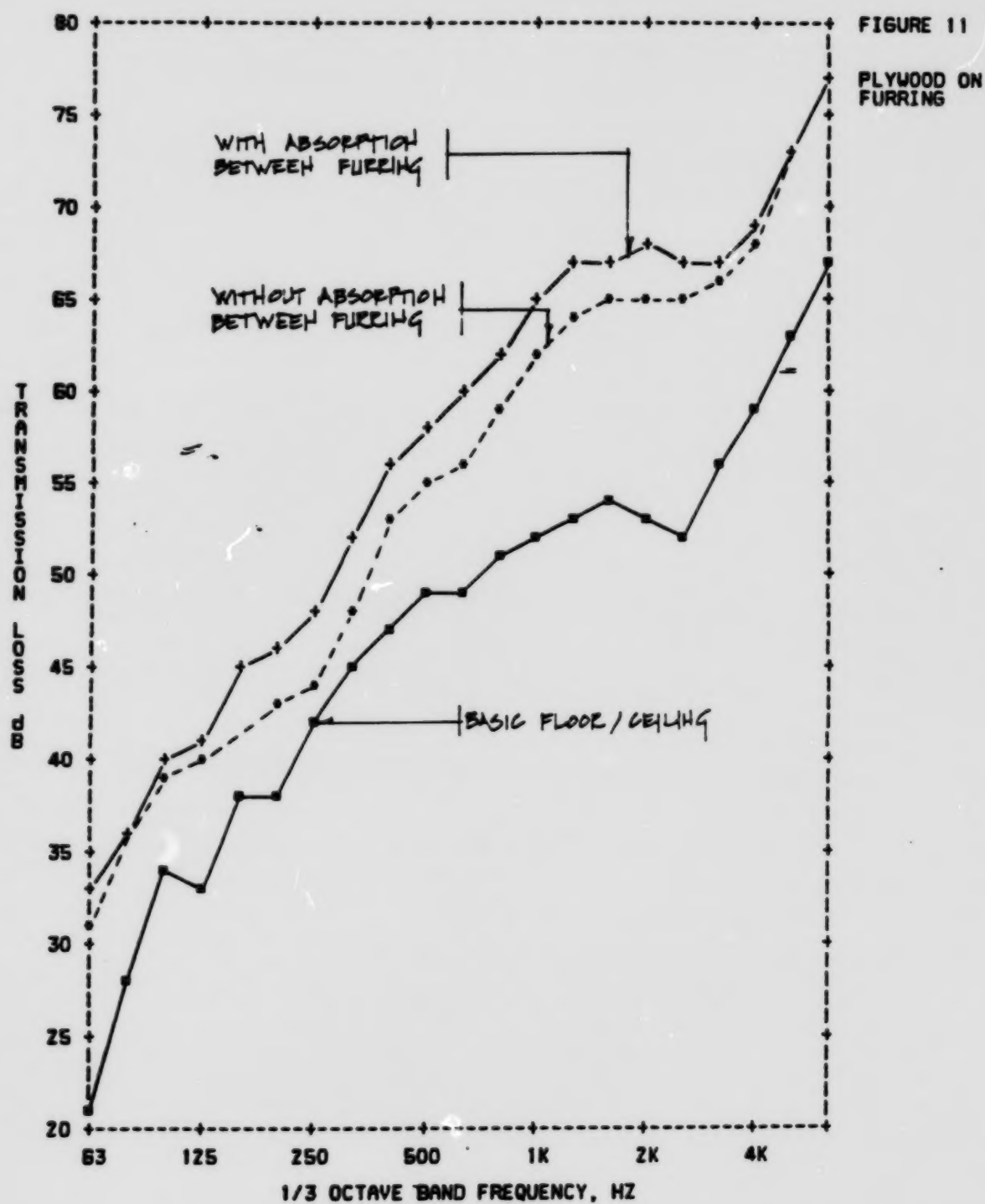
- FLOOR 12 IIC 53 16MM PLYWOOD
- + FLOOR 16 IIC 57 16MM PLYWOOD ON 11 MM WOOD FIBRE BOARD
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



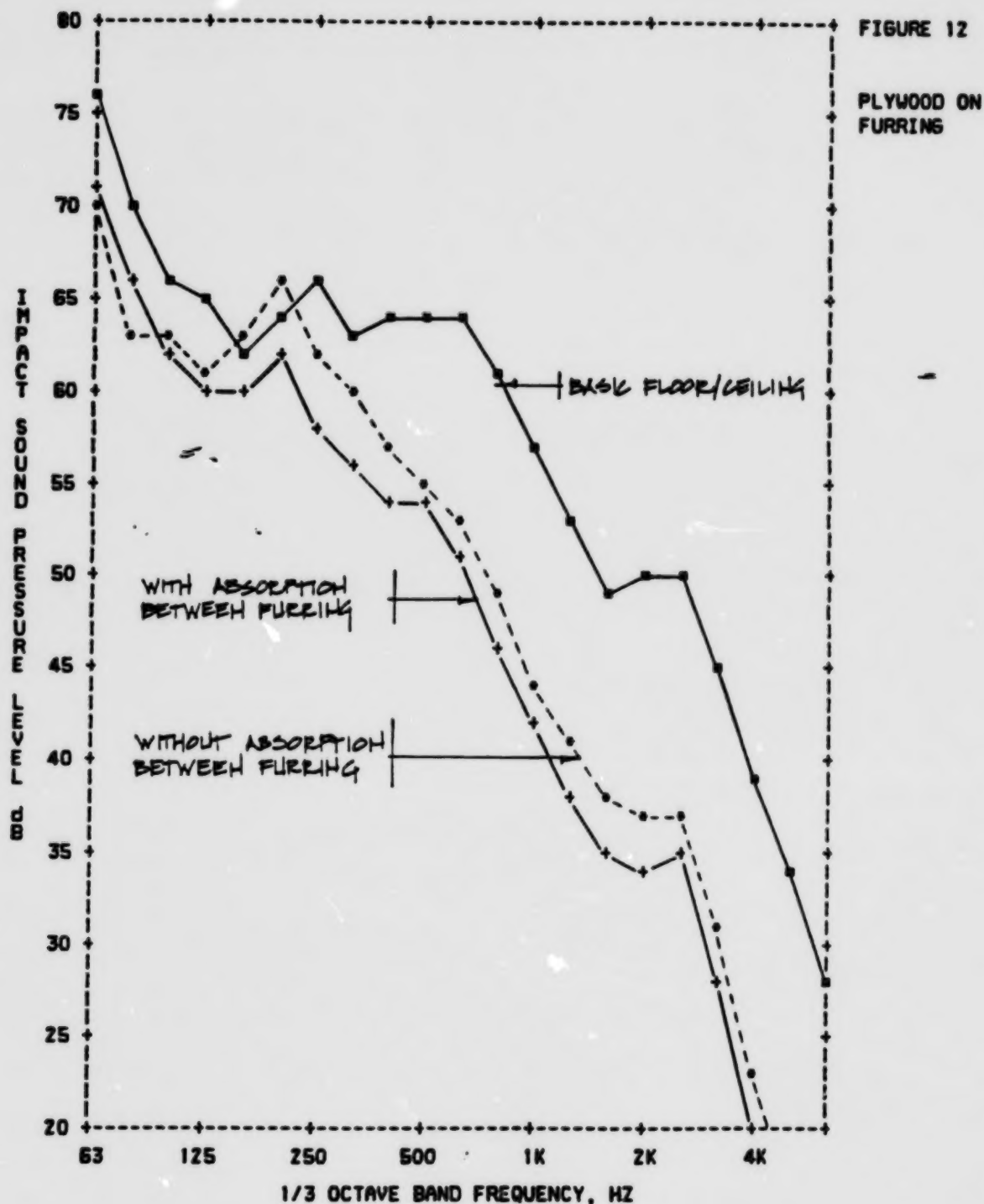
- FLOOR 12 STC 58 16MM PLYWOOD
- * FLOOR 22 STC 62 19MM CONCRETE
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



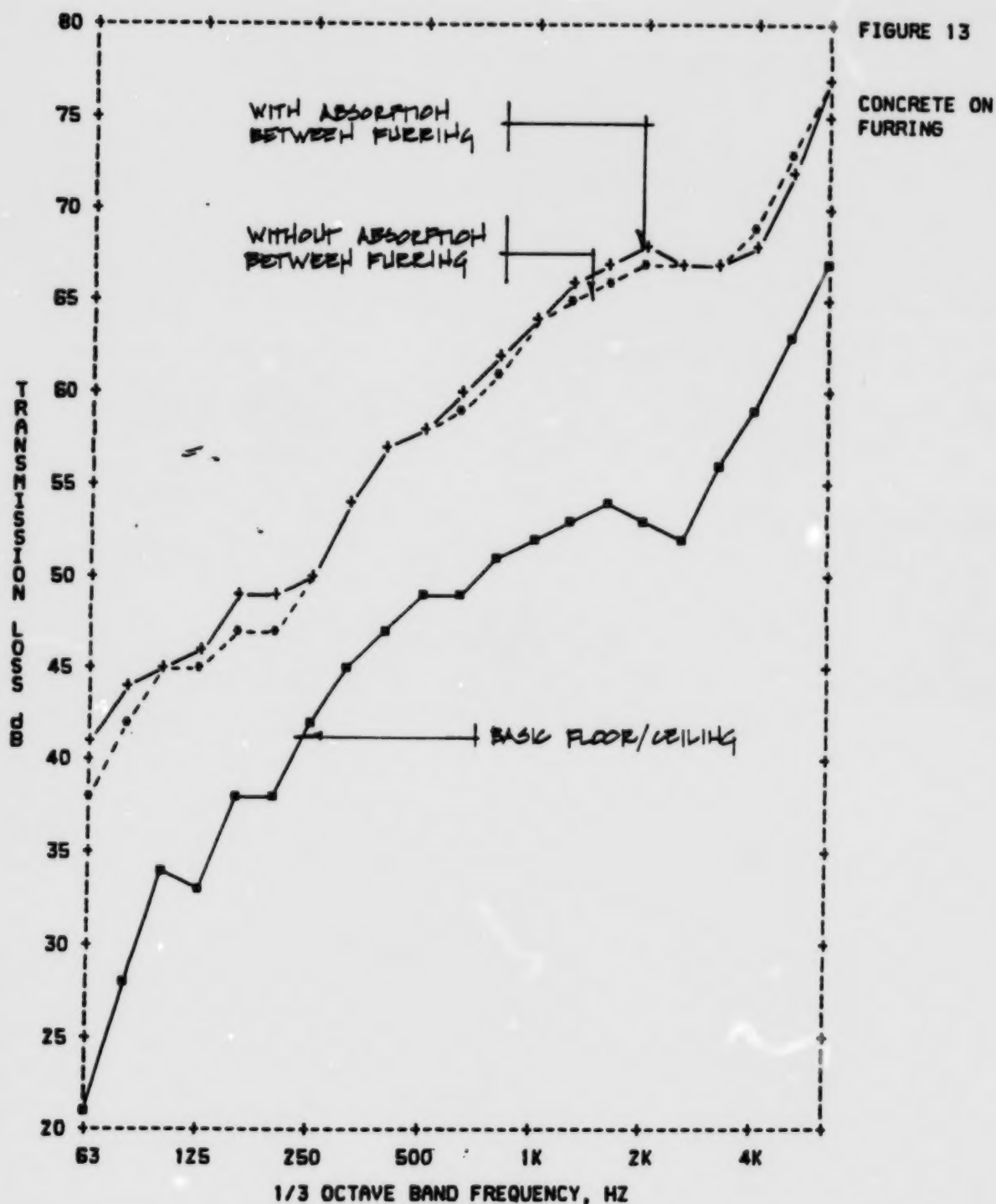
- FLOOR 12 IIC 53 16MM PLYWOOD
- * FLOOR 22 IIC 53 19MM CONCRETE
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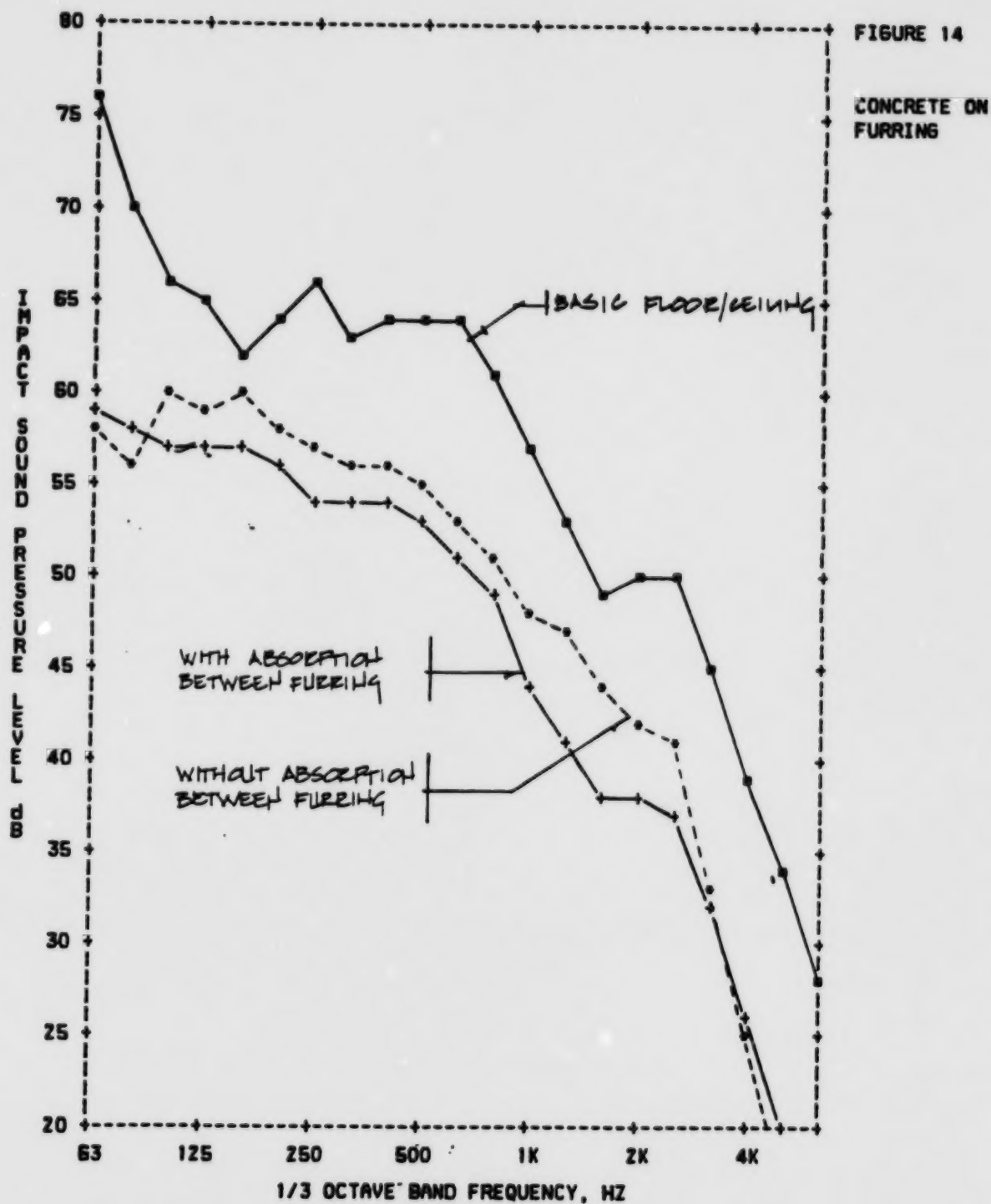
- FLOOR 13 STC 58 16MM PLYWOOD ON 16MM FURRING ON 3MM RUBBER
- + FLOOR 14 STC 60 16MM PLYWOOD ON 16MM FURRING ON 3MM RUBBER: ABSOR BTWN FURRING
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



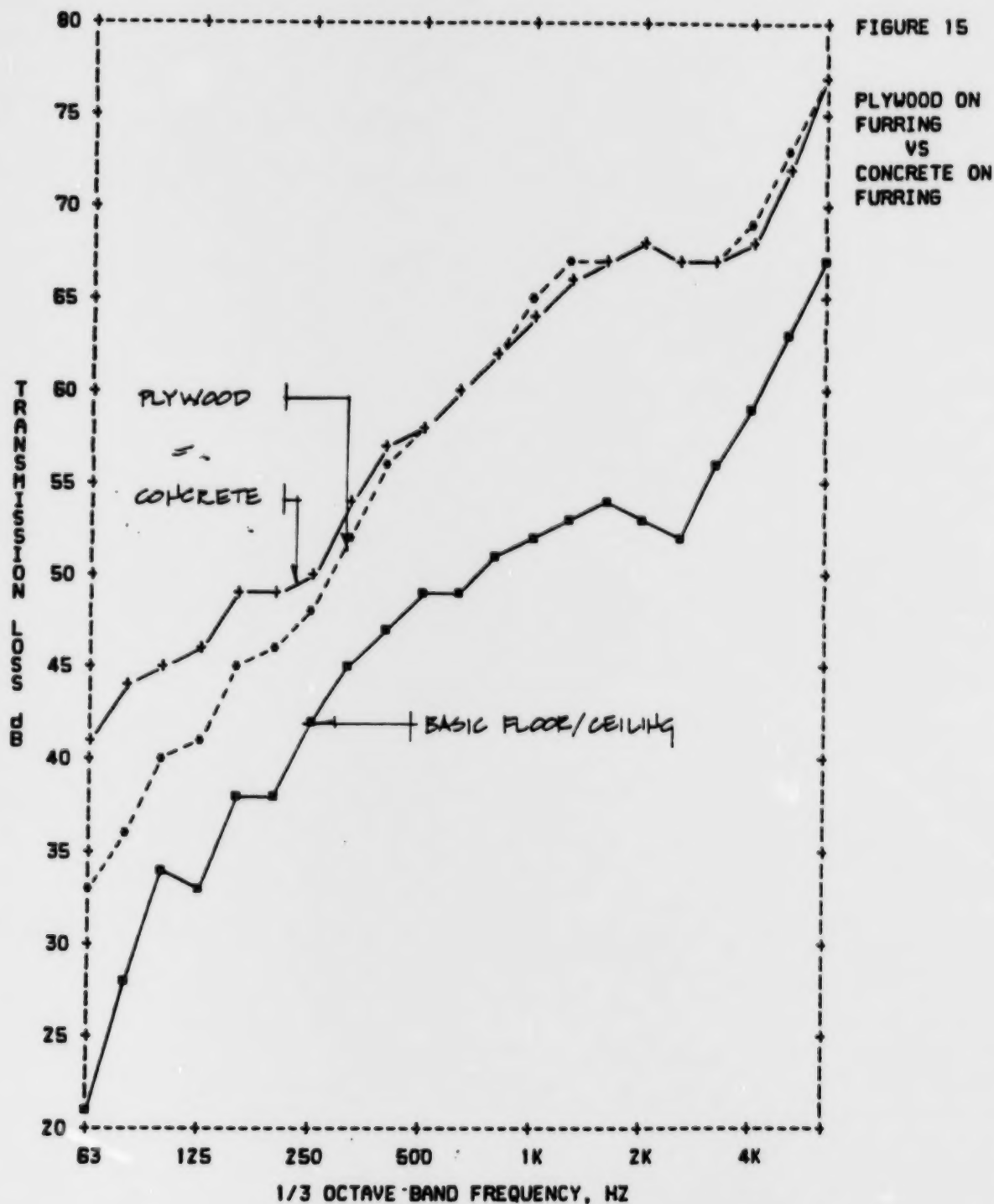
- FLOOR 13 IIC 54 16MM PLYWOOD ON 16MM FRANG ON 3MM RUBBER
- + FLOOR 14 IIC 57 16MM PLYWOOD ON 16MM FRANG ON 3MM RUBBER: ABSOR BTWN FRANG
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



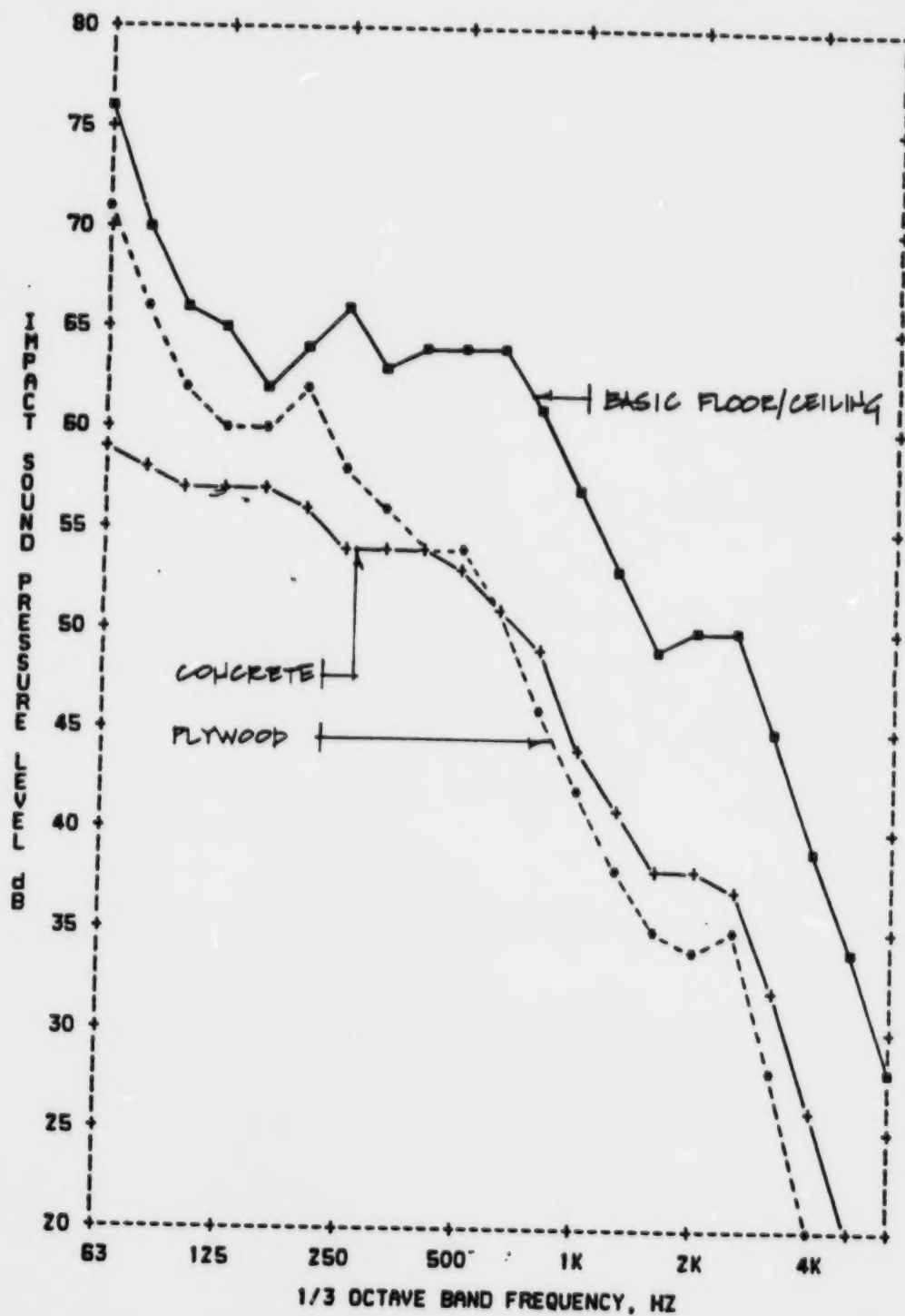
- FLOOR 10 STC 61 19mm CONCRETE ON 16mm FRRNG ON 3mm RUBBER
- + FLOOR 11 STC 62 19mm CONCRETE ON 16mm FRRNG ON 3mm RUBBER: ABSOR BTWN FRRNG
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



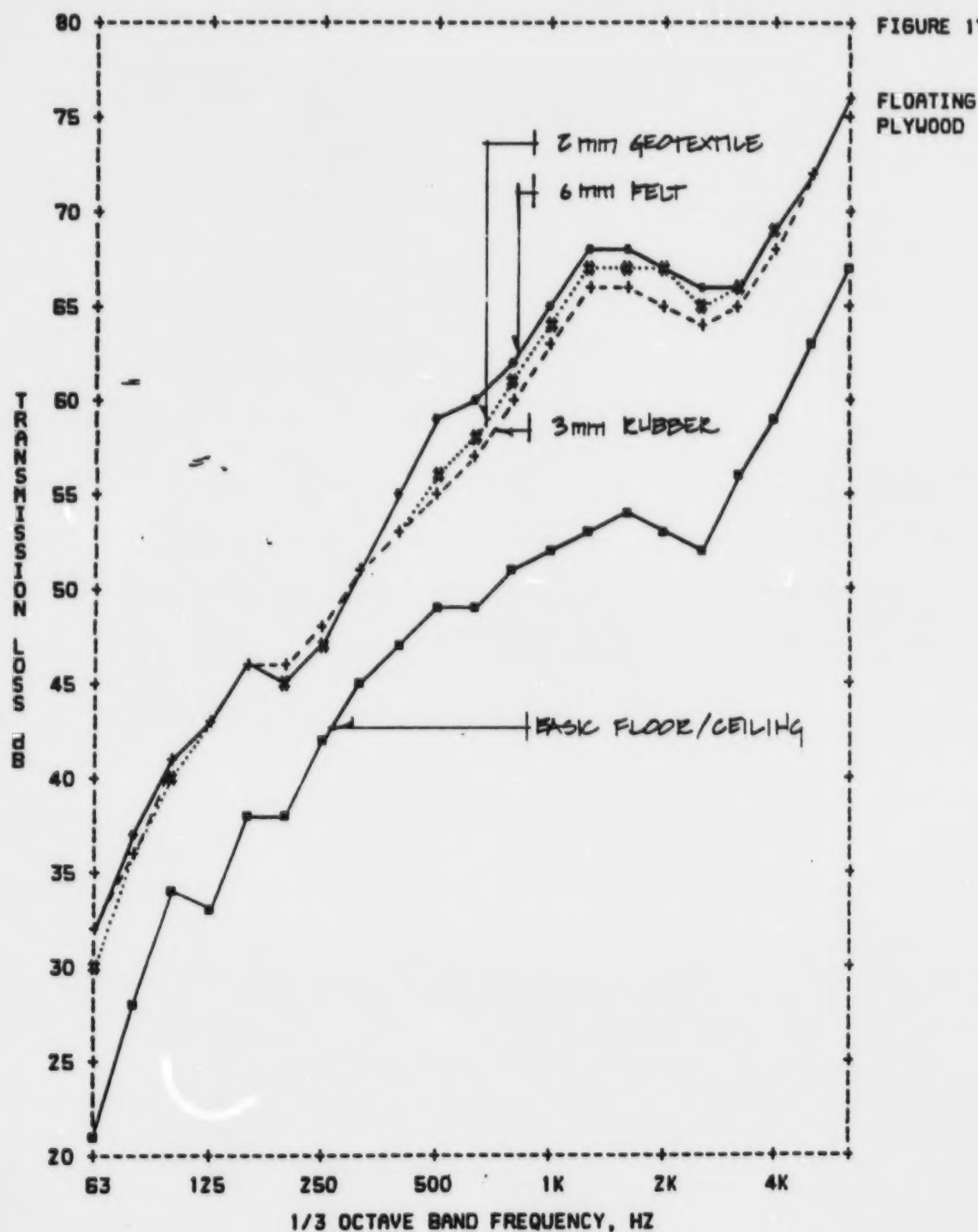
- FLOOR 10 IIC 57 19mm CONCRETE ON 16mm FRRNG ON 3mm RUBBER
- + FLOOR 11 IIC 59 19mm CONCRETE ON 16mm FRRNG ON 3mm RUBBER: ABSOR BTWN FRRNG
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



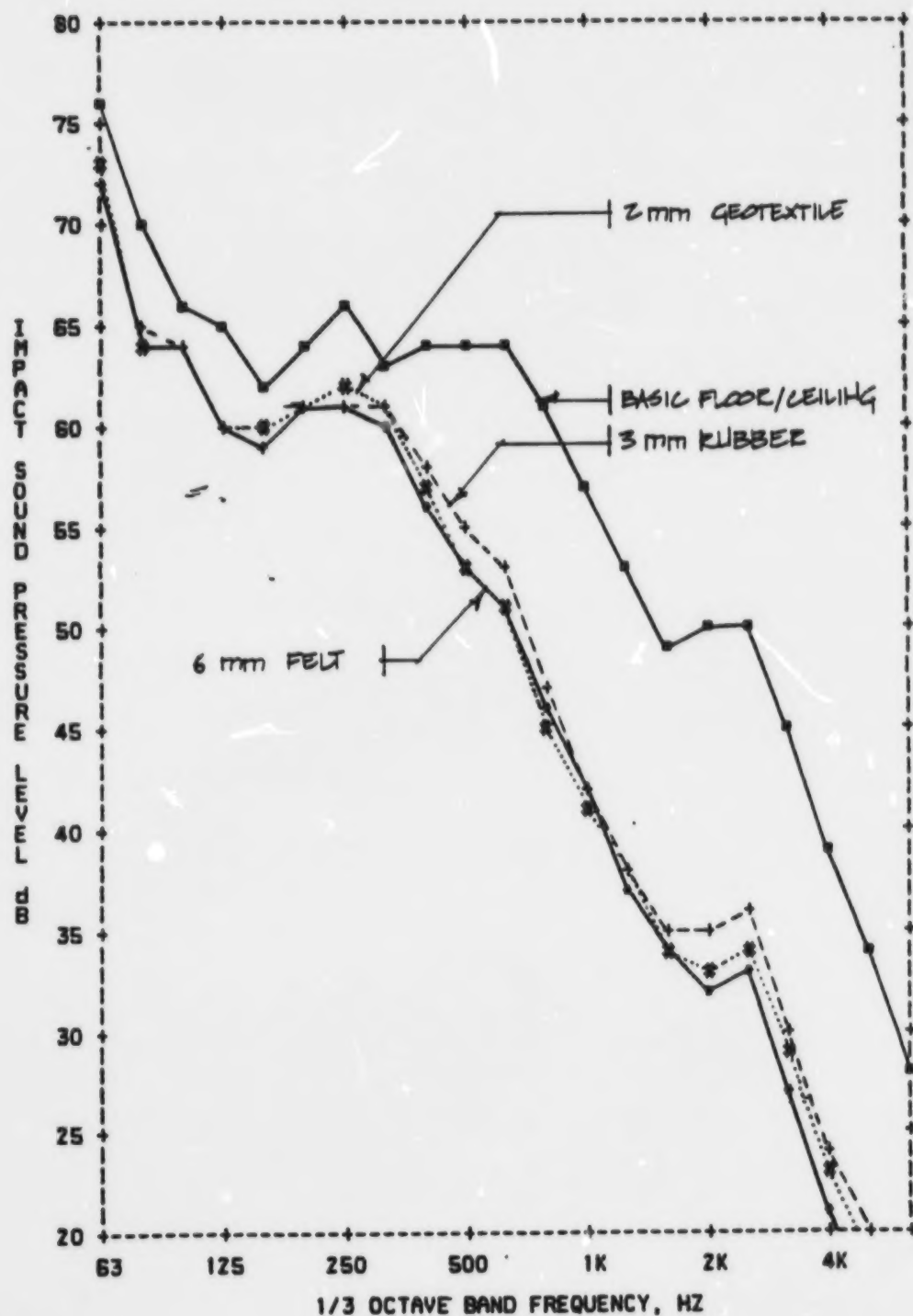
- FLOOR 14 STC 60 16MM PLYWOOD ON 16MM FRRNG ON 3MM RUBBER: ABSOR BTWN FRRNG
- + FLOOR 11 STC 62 19MM CONCRETE ON 16MM FRRNG ON 3MM RUBBER: ABSOR BTWN FRRNG
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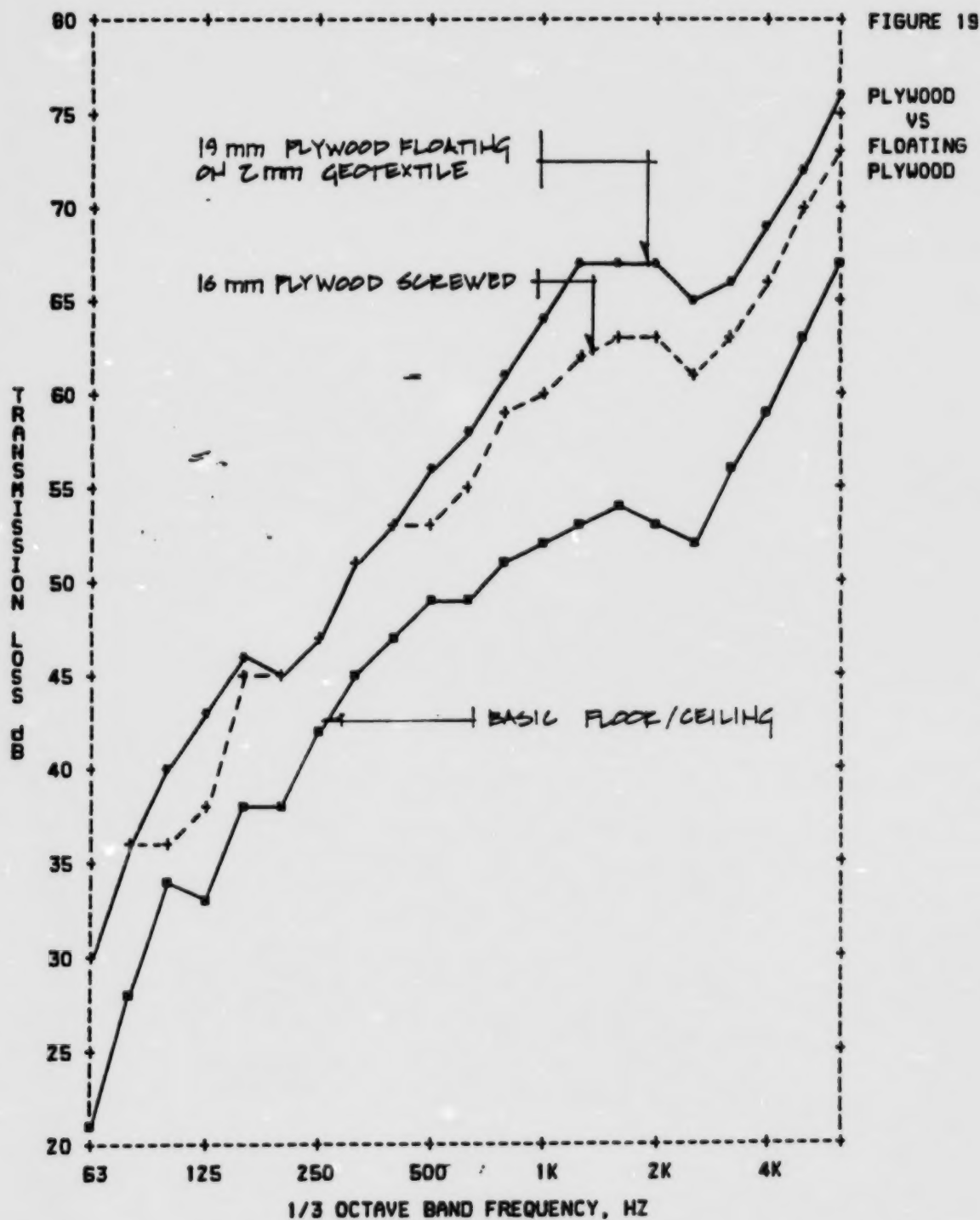
- FLOOR 14 IIC 57 16MM PLYWOOD ON 16MM FRRNG ON 3MM RUBBER: ABSOR BTWN FRRNG
- + FLOOR 11 IIC 59 19MM CONCRETE ON 16MM FRRNG ON 3MM RUBBER: ABSOR BTWN FRRNG
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



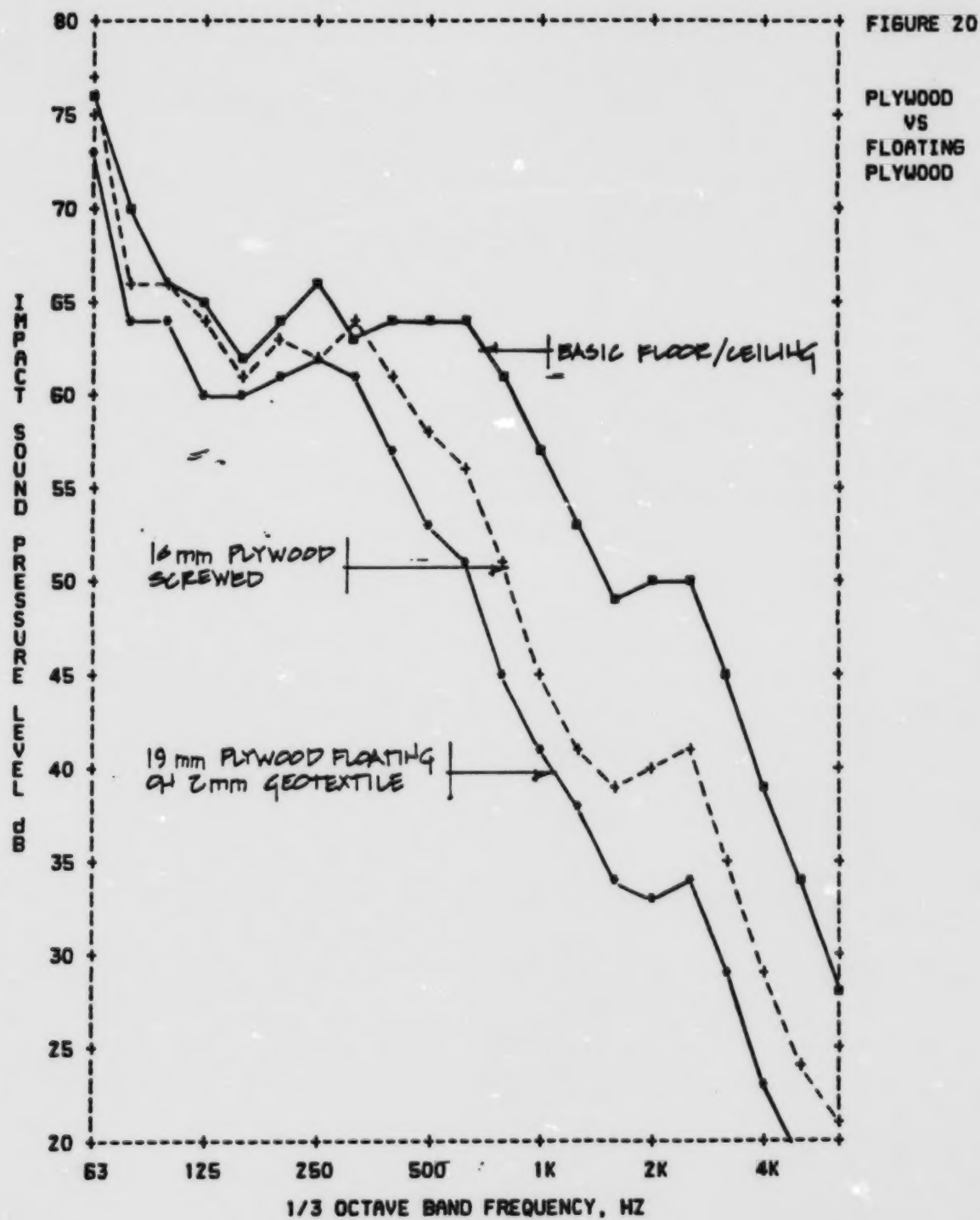
- FLOOR 19 STC 60 19mm PLYWOOD FLOATING ON 6 mm FELT UNDERPAD
- * FLOOR 20 STC 60 19mm PLYWOOD FLOATING ON 2mm GEOTEXTILE
- + FLOOR 21 STC 59 19mm PLYWOOD FLOATING ON 3mm RUBBER
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



- FLOOR 19 IIC 56 19mm PLYWOOD FLOATING ON 6mm FELT UNDERPAD
- * FLOOR 20 IIC 55 19mm PLYWOOD FLOATING ON 2mm GEOTEXTILE
- + FLOOR 21 IIC 55 19mm PLYWOOD FLOATING ON 3mm RUBBER
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



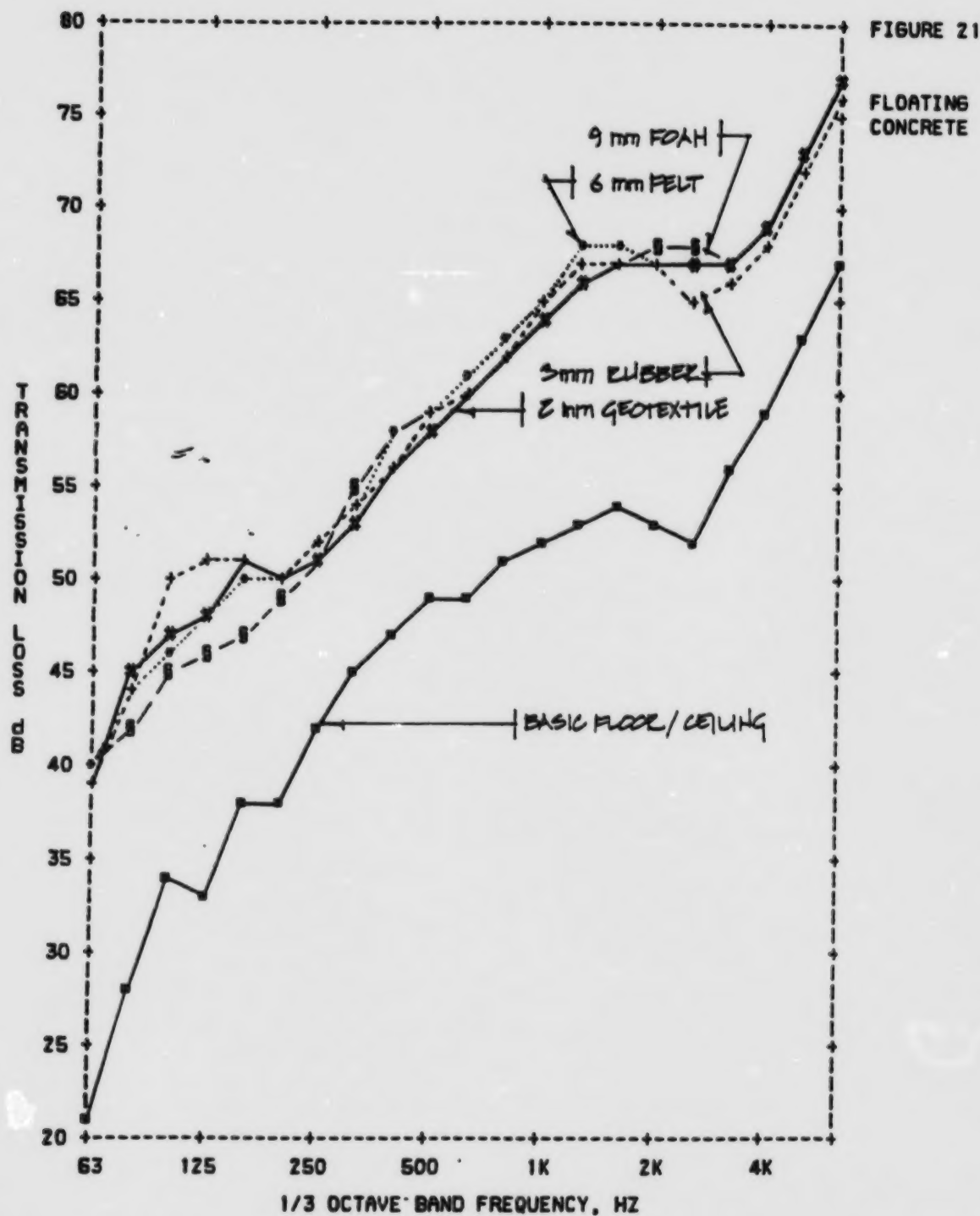
- + FLOOR 12 STC 58 16mm PLYWOOD
- FLOOR 20 STC 60 19mm PLYWOOD FLOATING ON 2mm GEOTEXTILE
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



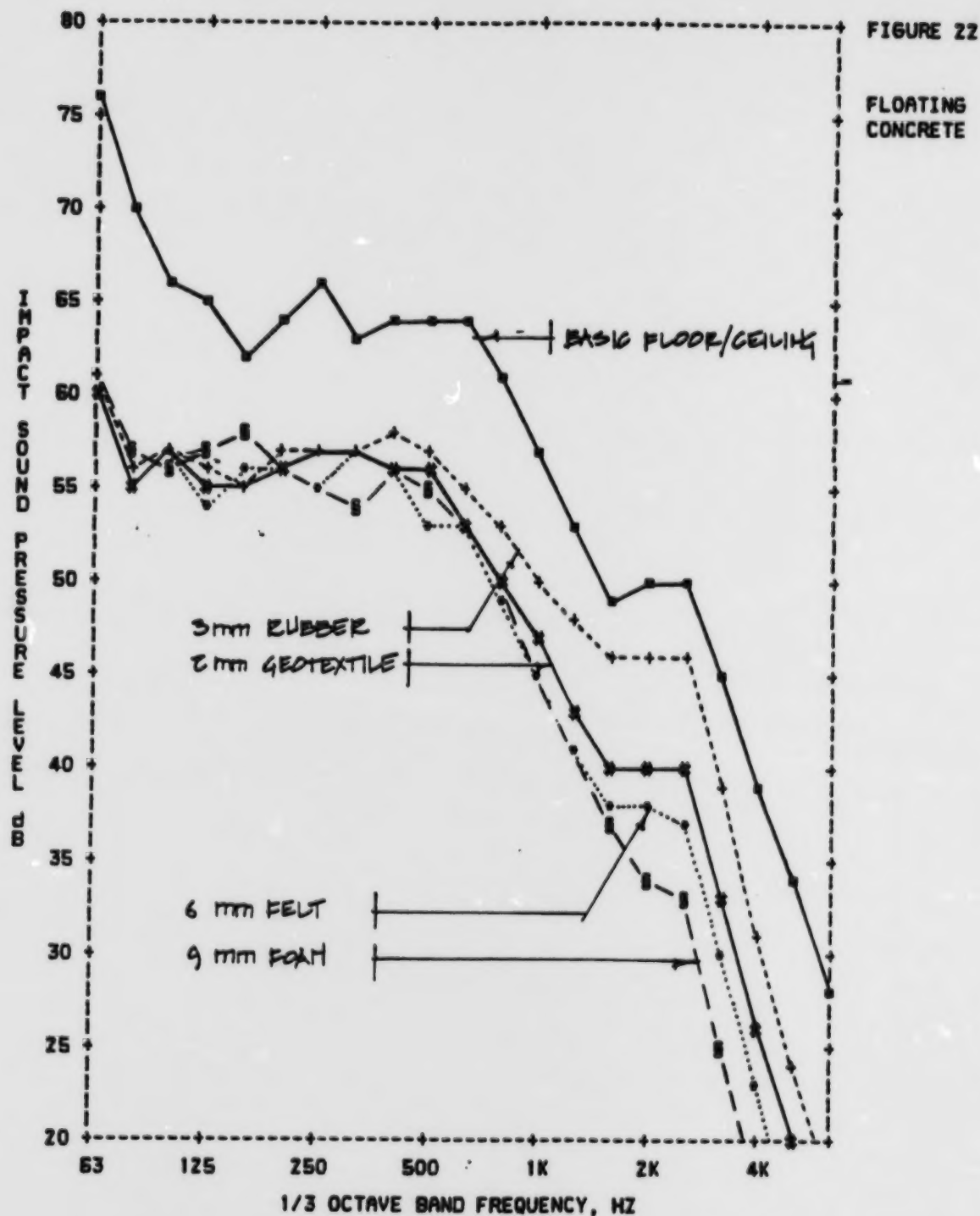
+ FLOOR 12 IIC 53 16mm PLYWOOD

• FLOOR 20 IIC 55 19mm PLYWOOD FLOATING ON 2mm GEOTEXTILE

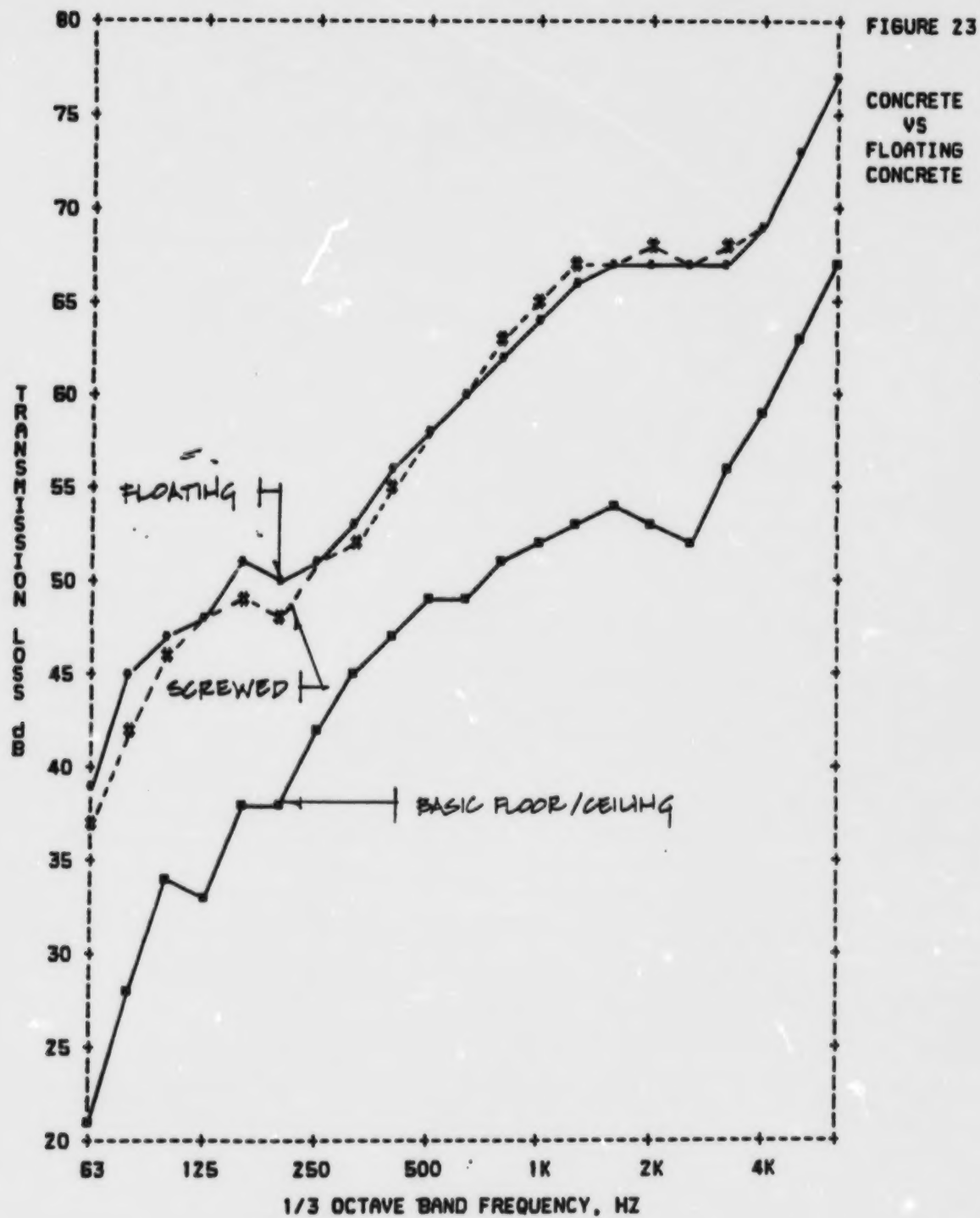
■ FLOOR 3 IIC 49 BASIC FLOOR/CEILING



- FLOOR 18 STC 63 19mm CONCRETE FLOATING ON 6mm FELT UNDERPAD
- * FLOOR 17 STC 62 19mm CONCRETE FLOATING ON 2mm GEOTEXTILE
- + FLOOR 8 STC 62 19mm CONCRETE FLOATING ON 3mm FOAM RUBBER
- FLOOR 9 STC 62 19mm CONCRETE FLOATING ON 9mm FOAM CARPET UNDERPAD
- FLOOR 3 STC 51 BASIC FLOOR/CEILING



- FLOOR 18 IIC 59 19mm CONCRETE FLOATING ON 6mm FELT UNDERPAD
- * FLOOR 17 IIC 58 19mm CONCR. E FLOATING ON 2mm GEOTEXTILE
- + FLOOR 8 IIC 56 19mm CONCRETE FLOATING ON 3mm FOAM RUBBER
- FLOOR 9 IIC 59 19mm CONCRETE FLOATING ON 9mm FOAM CARPET UNDERPAD
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING

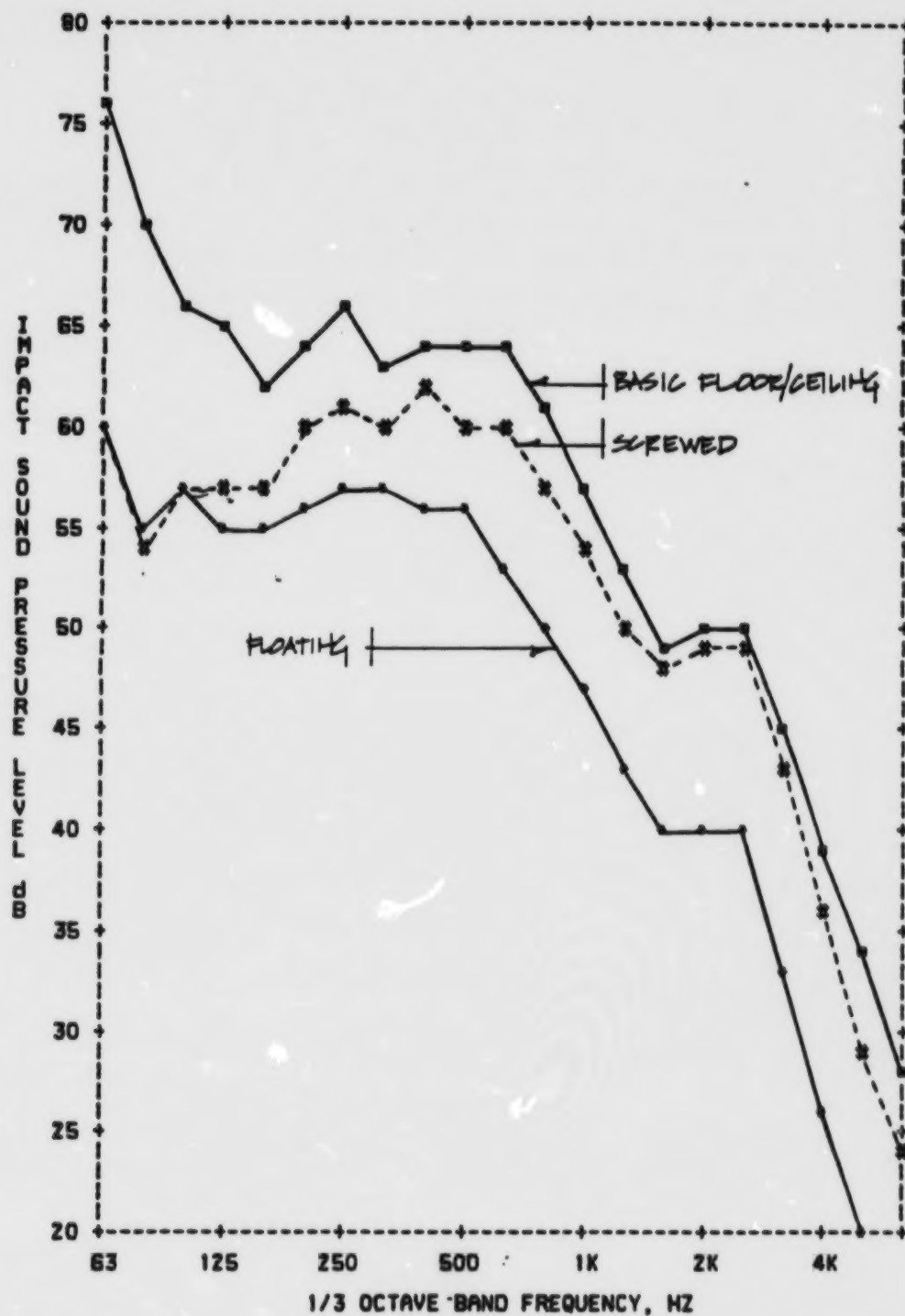


* FLOOR 22 STC 62 19mm CONCRETE

• FLOOR 17 STC 62 19mm CONCRETE FLOATING ON 2mm GEOTEXTILE

• FLOOR 3 STC 51 BASIC FLOOR/CEILING

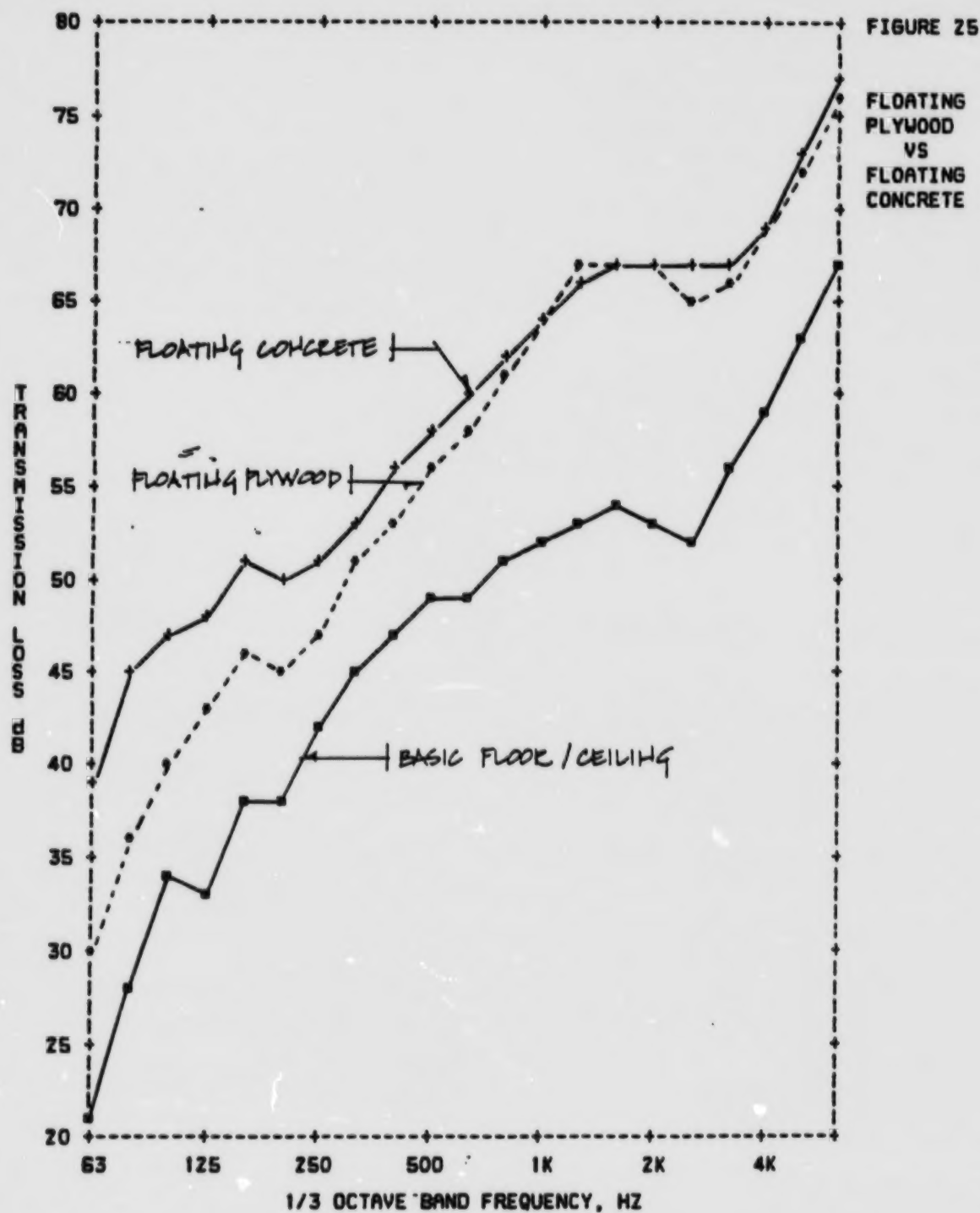
FIGURE 24

CONCRETE
VS
FLOATING
CONCRETE

* FLOOR 22 IIC 53 19mm CONCRETE

• FLOOR 17 IIC 58 19mm CONCRETE FLOATING ON 2mm GEOTEXTILE

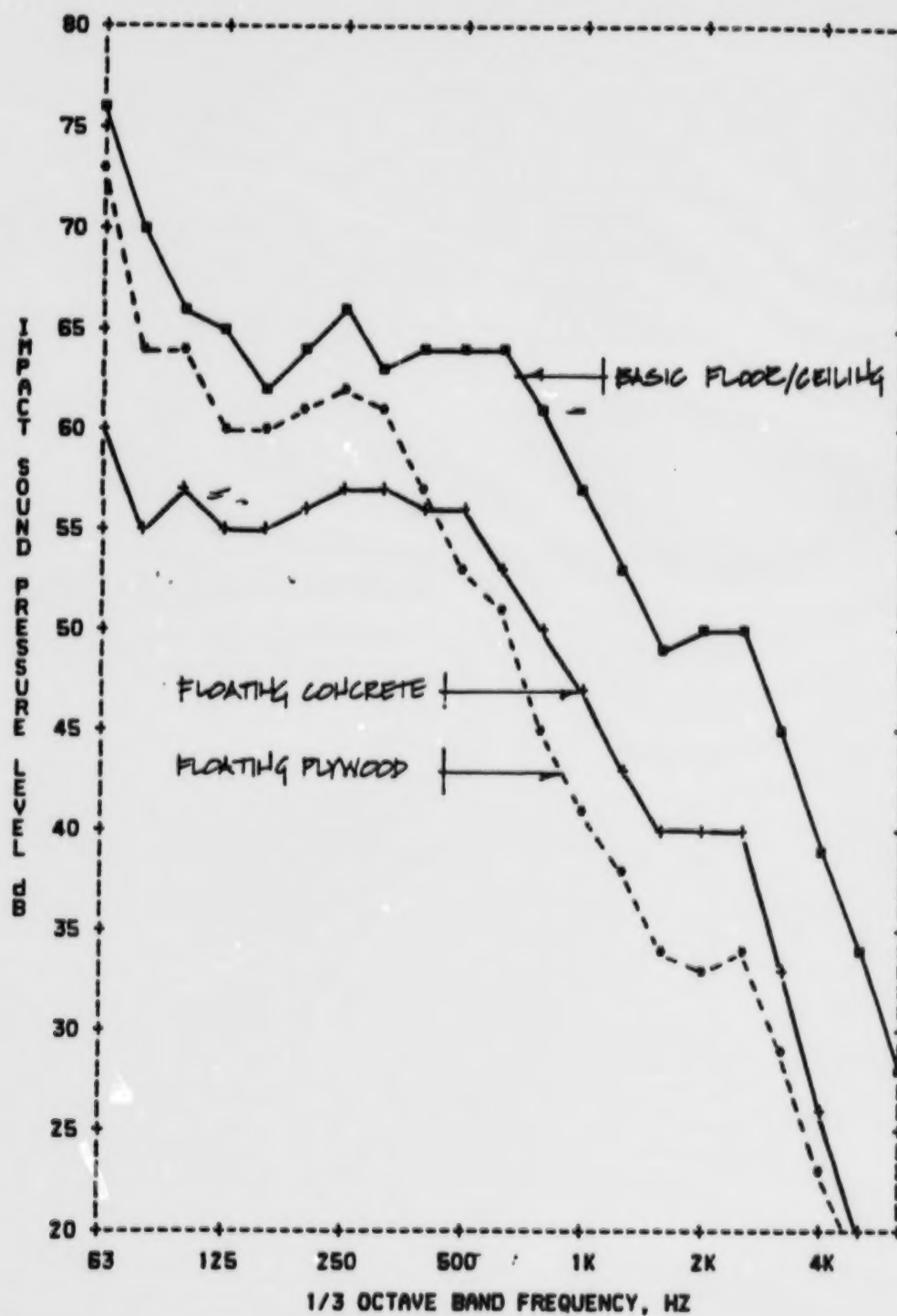
■ FLOOR 3 IIC 49 BASIC FLOOR/CEILING



- FLOOR 20 STC 60 19MM PLYWOOD FLOATING ON 2MM GEOTEXTILE
- + FLOOR 17 STC 62 19MM CONCRETE FLOATING ON 2MM GEOTEXTILE
- FLOOR 3 STC 51 BASIC FLOOR/CEILING

FIGURE 26

FLOATING
PLYWOOD
VS
FLOATING
CONCRETE



- FLOOR 20 IIC 55 19MM PLYWOOD FLOATING ON 2MM GEOTEXTILE
- ♦ FLOOR 17 IIC 58 19MM CONCRETE FLOATING ON 2MM GEOTEXTILE
- FLOOR 3 IIC 49 BASIC FLOOR/CEILING



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CLIENT REPORT

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Tests on Floors for Airborne and Impact Sound Transmission

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Report No. CR-5949.1

Report Date: 26 April 1990

Contract No. CR-5949

Reference: Application for test dated 14 July 1989

Section: Acoustics

54 Pages

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The sound transmission data presented in this report were collected as part of a measurement series to examine the effects of making changes to the floor surface of a wood joist floor system. The sound transmission and impact transmission data are presented in graphical and tabular form in Appendix A.

MEASUREMENT FACILITIES

In the IRC acoustical facility, the floor test opening measures 2.4 x 2.4 m. The upper room has a volume of 120 m³ while the lower room has a volume of 65 m³. Each room contains nine calibrated GenRad electret condenser microphones, four incoherently excited random noise sources and fixed diffusing panels. The lower room also has moving diffusing panels. For airborne and impact sound transmission, the receiving room is the lower room.

MEASUREMENT PROCEDURES

Measurements are controlled by a desktop PC-type computer interfaced to a Norwegian Electronics 830 real time analyser. Sound pressure levels are measured for 15 seconds at each microphone position and then averaged to get the mean value for the room. Five sound decays are averaged to get reverberation times at each of the nine microphone positions. These times are averaged to get reverberation times for the room.

Measurements and calculations of sound transmission were made in accordance with the requirements of ASTM E90.

Measurements of impact sound transmission were made in accordance with the requirements of ASTM E492 using the standard tapping machine and the prescribed five impact positions on the floor.

BASIC FLOOR DESCRIPTION

A rectangular frame formed from 38 x 235 mm wood joists was bolted directly to the concrete of the upper part of the test opening. Wood joists measuring 38 x 235 mm at 400 mm centres were attached to this frame using joist hangers and toe-nails; 16 mm tongued and grooved plywood was screwed on top of the joists with screws 400 mm on centres. The weight per unit area of the basic floor was 18.7 kg/m².

For the majority of the tests, the basic floor was finished by inserting three layers of glass fibre batts in the joist spaces, attaching resilient metal channels at 600 mm centres to the underside of the joists, and attaching two layers of 16 mm gypsum wallboard to the channels. The weight per unit area of this floor was 44.5 kg/m². All peripheral and other gaps were caulked to form an airtight seal.

Two slabs were constructed for use as floating floors. One was constructed from two sheets of 6 mm wonderboard laminated together using about 6 mm of

mortar. The thickness of the finished slab was 19 mm. The second slab was constructed from two layers of 9 mm plywood glued and screwed together to form a 19 mm thick layer. These slabs were laid directly on the various resilient underlayments; no screws were used to hold them in place.

In floor 12, the upper plywood layer was screwed to the layer beneath. In floors 13 and 14, the upper plywood layer was screwed to the furring strips. In floor 16, the wood fibre board was stapled and glued to the upper layer of plywood. The resulting slab was then laid on the basic floor.

Two carpets were used during the study:

1. a brown foam-backed carpet with a total thickness of 10 mm. The pile was 5 mm thick, the jute backing was 1 mm thick and the foam layer was 4 mm thick. The weight was 2.31 kg/m²;
2. a grey loop pile carpet with a total thickness of 10 mm. The pile was 9 mm thick and the jute backing was 1 mm thick. The weight was 2.94 kg/m².

Weights and thicknesses for the materials used during the project are given in the table on the following page. The thickness listed is the material thickness or the thickness added to the floor, as appropriate.

SUMMARY OF RESULTS

For convenience, Table 1 gives a short description of each floor tested, the IRC test identifiers, and the STC and IIC ratings.

Appendix A repeats the description for each floor system tested, and tabulates and plots the data for sound transmission loss and impact sound transmission. For each test, in the frequency ranges governed by the appropriate standard, the required confidence limits were satisfied. To avoid needless repetition, however, the measured confidence limits are not given in this report.

Material	Thickness (mm)	Weight (kg/m ²)
Tongued and grooved fir plywood	16	7.52
Laminated fir plywood slab	19	9.00
38 x 230 mm spruce floor joists @ 400 mm centres	230	11.15
R-12 Fiberglass Home Insulation	90	1.22
25 ga. resilient metal channels @ 600 mm centres	13	0.24
Gypsum wallboard	16	11.1
SCI closed cell neoprene foam	3	0.63
Blue foam carpet underlay	9	0.40
Felt carpet underpad (coated one side)	6	1.70
Mirafi geotextile material (non-woven fabric)	2	0.16
#15 Saturated building paper	1	0.53
Wood fibreboard, treated Ten-Test	11	2.91
Rigid glass fibre panels (ceiling tiles)	16	1.42
16 x 70 mm wood furring strips @ 400 mm centres on 3 mm SCI neoprene foam	19	1.60
Wonderboard	6	10.6
2 layers of Wonderboard laminated with 6 mm mortar (cement slurry)	19	23.2
Grey loop pile carpet	10	2.94
Brown foam-backed carpet	10	2.3

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
1	- 16 mm tongue and groove plywood - 240 mm wood joists - 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-006	52	II-90-006	48
2	- 16 mm tongue and groove plywood - 240 mm wood joists - 2 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-89-072	52	II-89-012	48
3	- 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-89-064	51	II-89-005	49
4	- Grey carpet - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-89-065	54	II-89-006	63
5	- Brown foam-backed carpet - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-89-068	55	II-89-011	65

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IRC
6	- Grey carpet - 6 mm felt underpad - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL 89-067	56	II-89-010	69
7	- Grey carpet - 9 mm foam carpet underpad - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL 89-066	55	II-89-007	81
8	- 2 layers of 6 mm Wonderboard laminated together - 3 mm closed cell neoprene foam - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL 90-012	62	II-90-011	56
9	- 2 layers of 6 mm Wonderboard laminated together - 9 mm foam carpet underpad - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL 90-015	62	II-90-012	59

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
10	- 2 layers of 6 mm Wonderboard laminated together - 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-016	61	II-90-013	57
11	- 2 layers of 6 mm Wonderboard laminated together - 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside - 16 mm panels of rigid glass fibre between furring strips (ceiling tiles) - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-017	62	II-90-014	59
12	- 16 mm tongue and groove plywood - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-020	58	II-90-017	53
13	- 16 mm tongue and groove plywood - 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-019	58	II-90-016	54

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
14	- 16 mm tongue and groove plywood - 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside - 16 mm panels of rigid glass fibre between furring strips (ceiling tiles) - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-018	60	II-90-015	57
15	- 16 mm tongue and groove plywood - 1 mm thick saturated building paper - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-021	58	II-90-018	52
16	- 16 mm tongue and groove plywood - 11 mm wood fibre board - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-022	61	II-90-019	57
17	- 2 layers of 6 mm Wonderboard laminated together - 2 mm geotextile material, Mirafi - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-023	62	II-90-020	58

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
18	- 2 layers of 6 mm Wonderboard laminated together - 6 mm felt underpad - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-024	63	II-90-021	59
19	- 2 layers of 9 mm plywood laminated together - 6 mm felt underpad - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-025	60	II-90-022	56
20	- 2 layers of 9 mm plywood laminated together - 2 mm geotextile material, Mirall - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-026	60	II-90-023	55
21	- 2 layers of 9 mm plywood laminated together - 3 mm closed cell neoprene foam - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-027	59	II-90-024	55

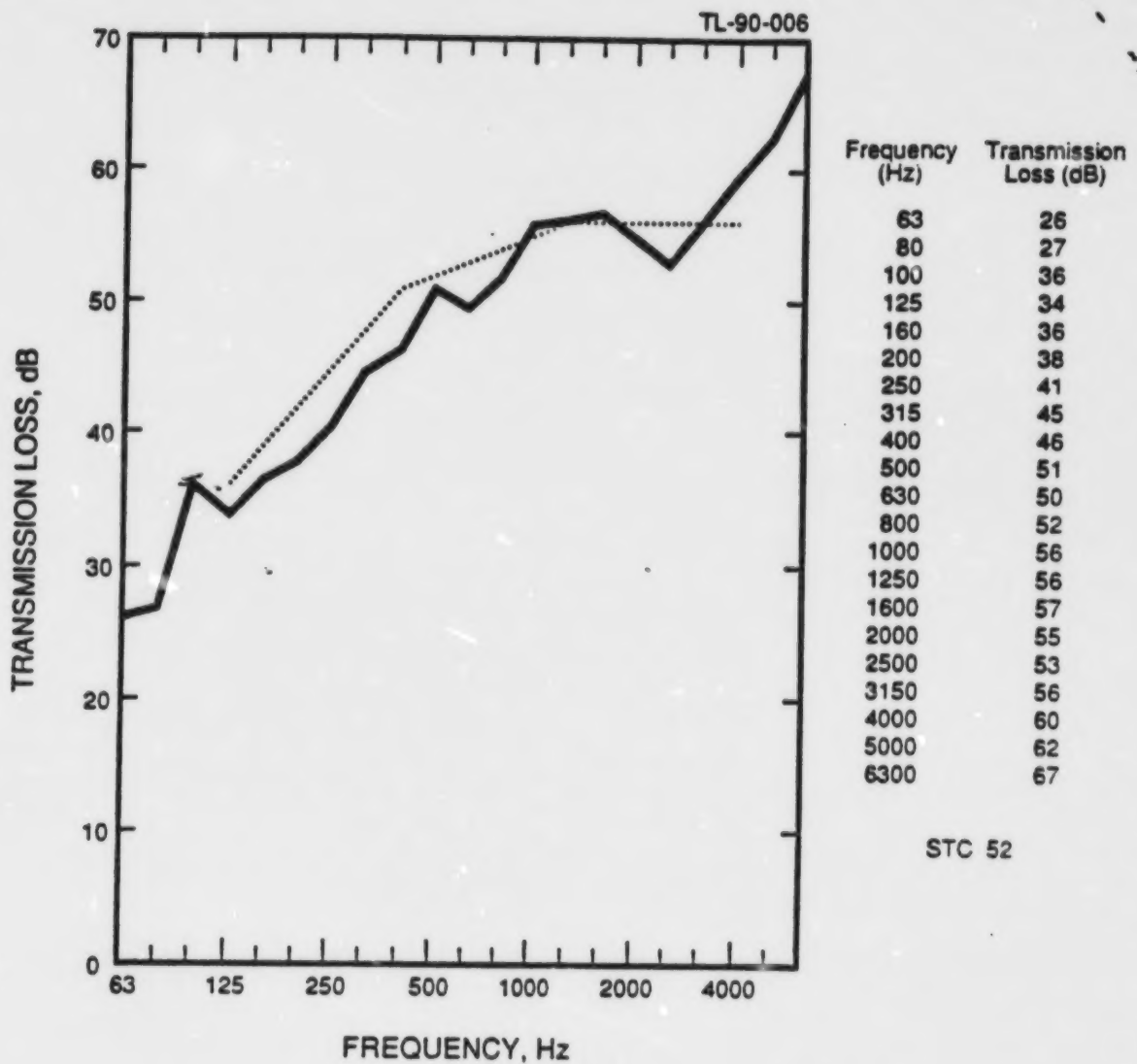
TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
22	- 2 layers of 6 mm Wonderboard laminated together - 16 mm tongue and groove plywood - 240 mm wood joists - 3 layers of 90 mm glass fibre batt insulation - 13 mm resilient metal channels - 2 layers of 16 mm drywall	TL-90-040	62	II-90-025	53

APPENDIX A

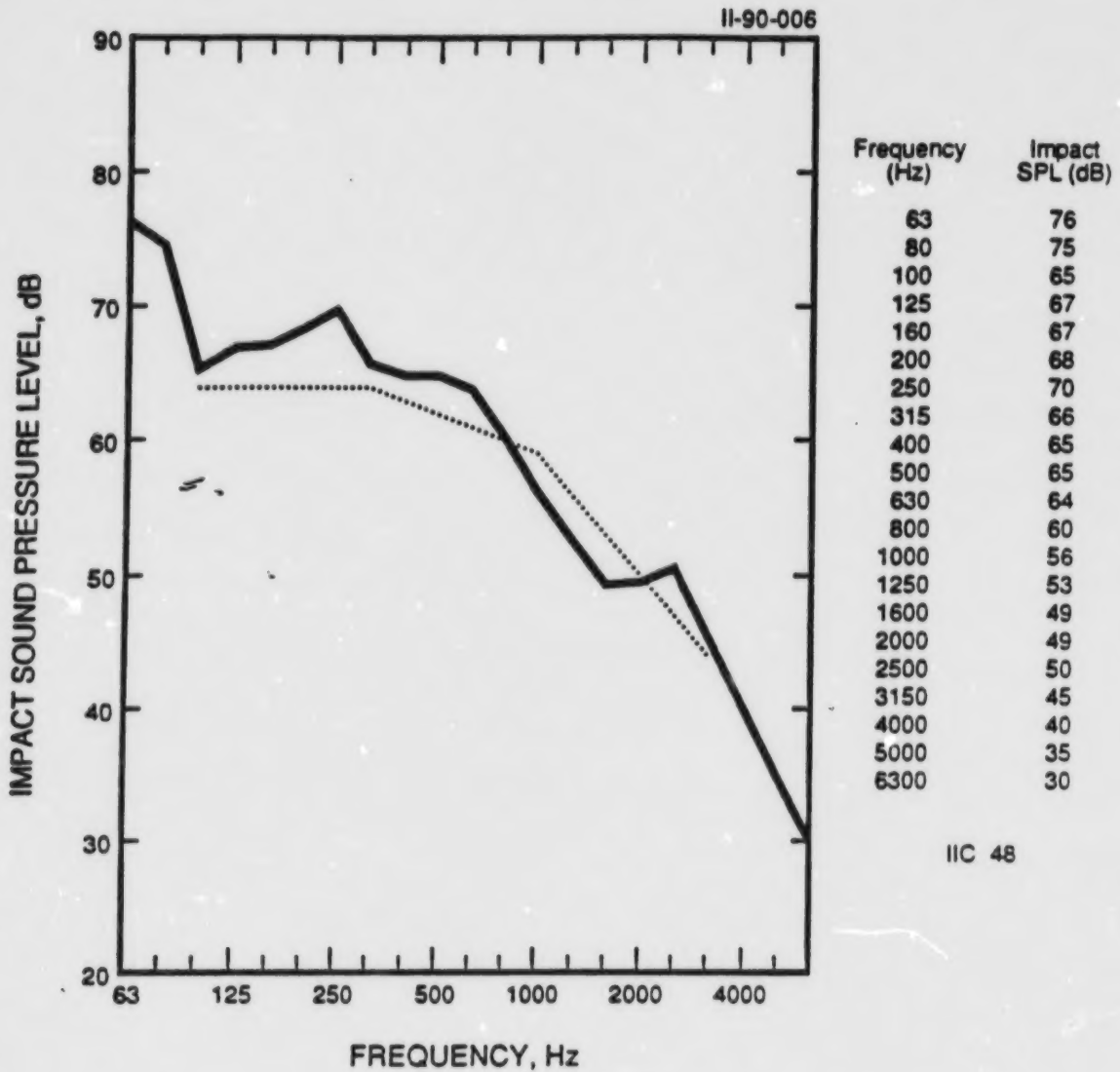
Individual Sound Transmission Loss and Impact Sound

Level Data



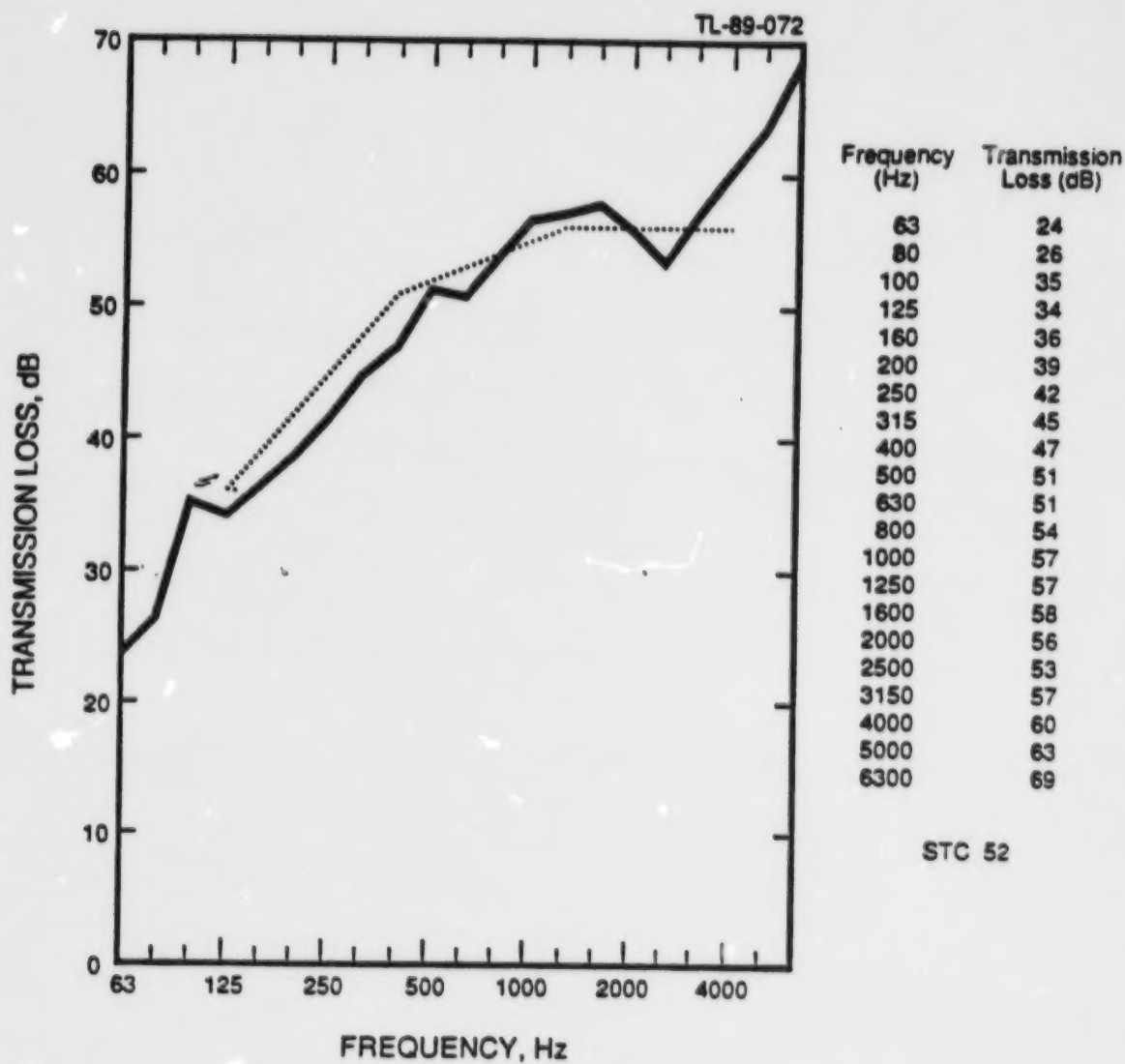
Floor 1: TL90-006

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



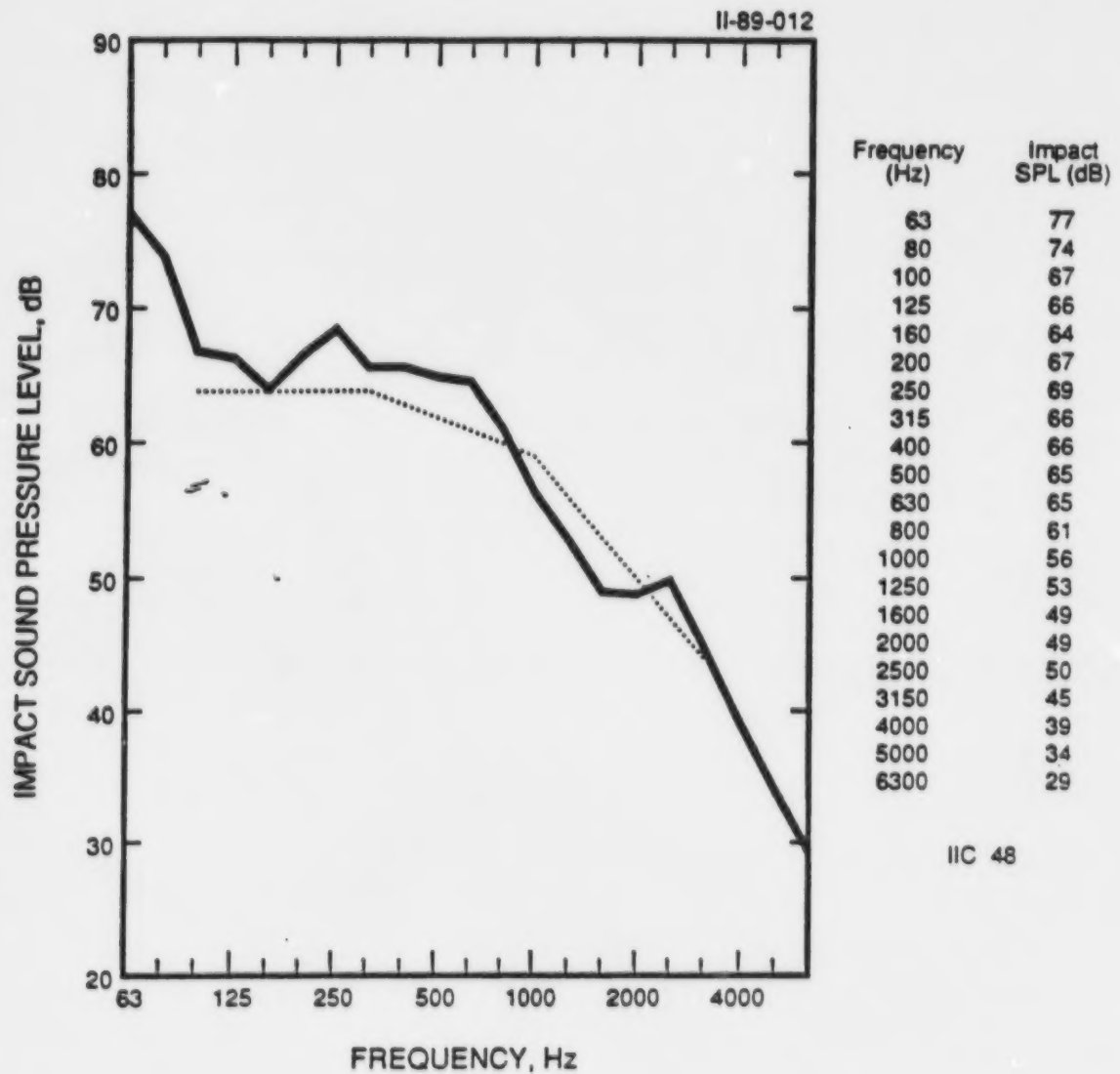
Floor 1: II-90-006

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



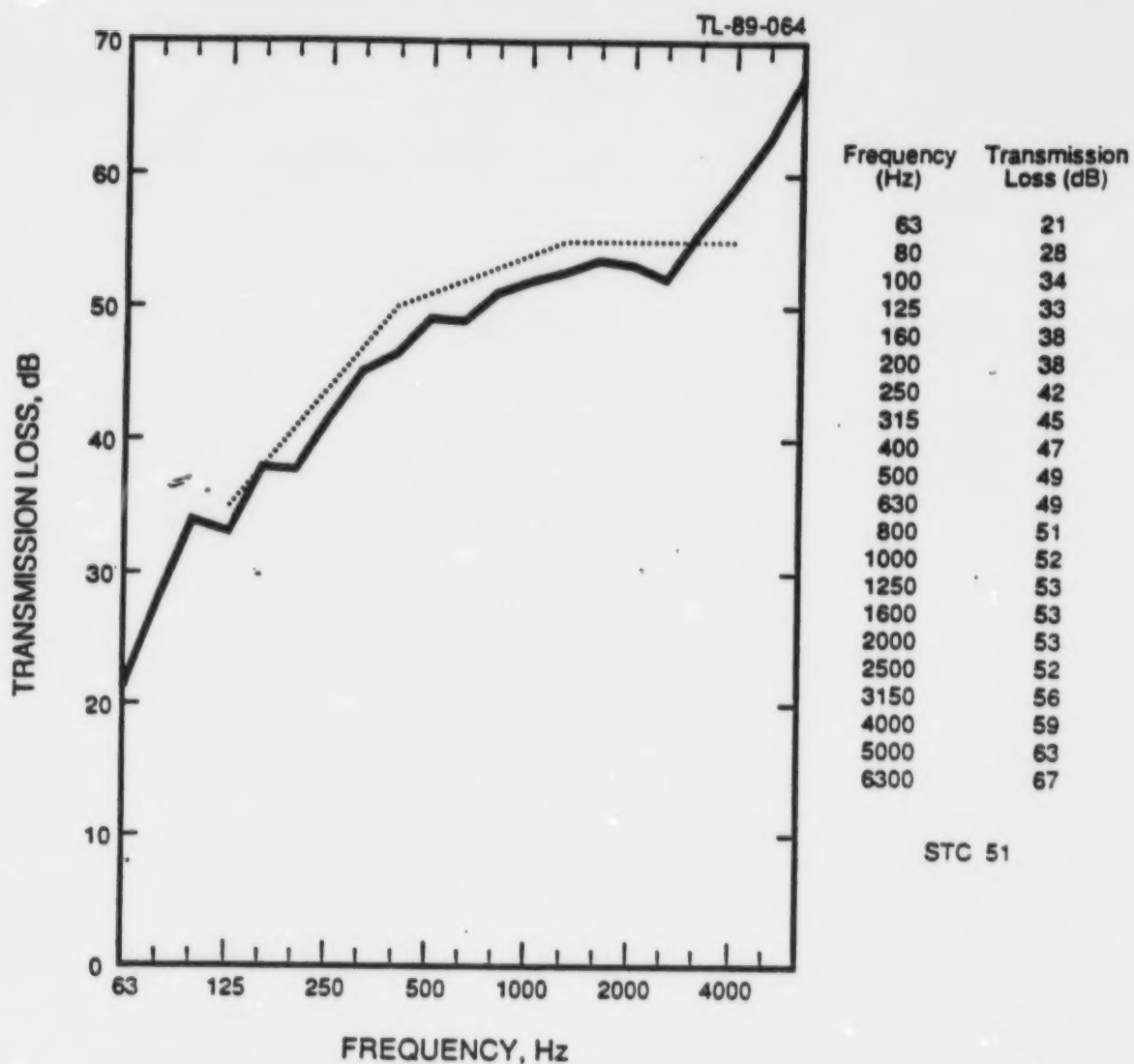
Floor 2: TL-89-072

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 2 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



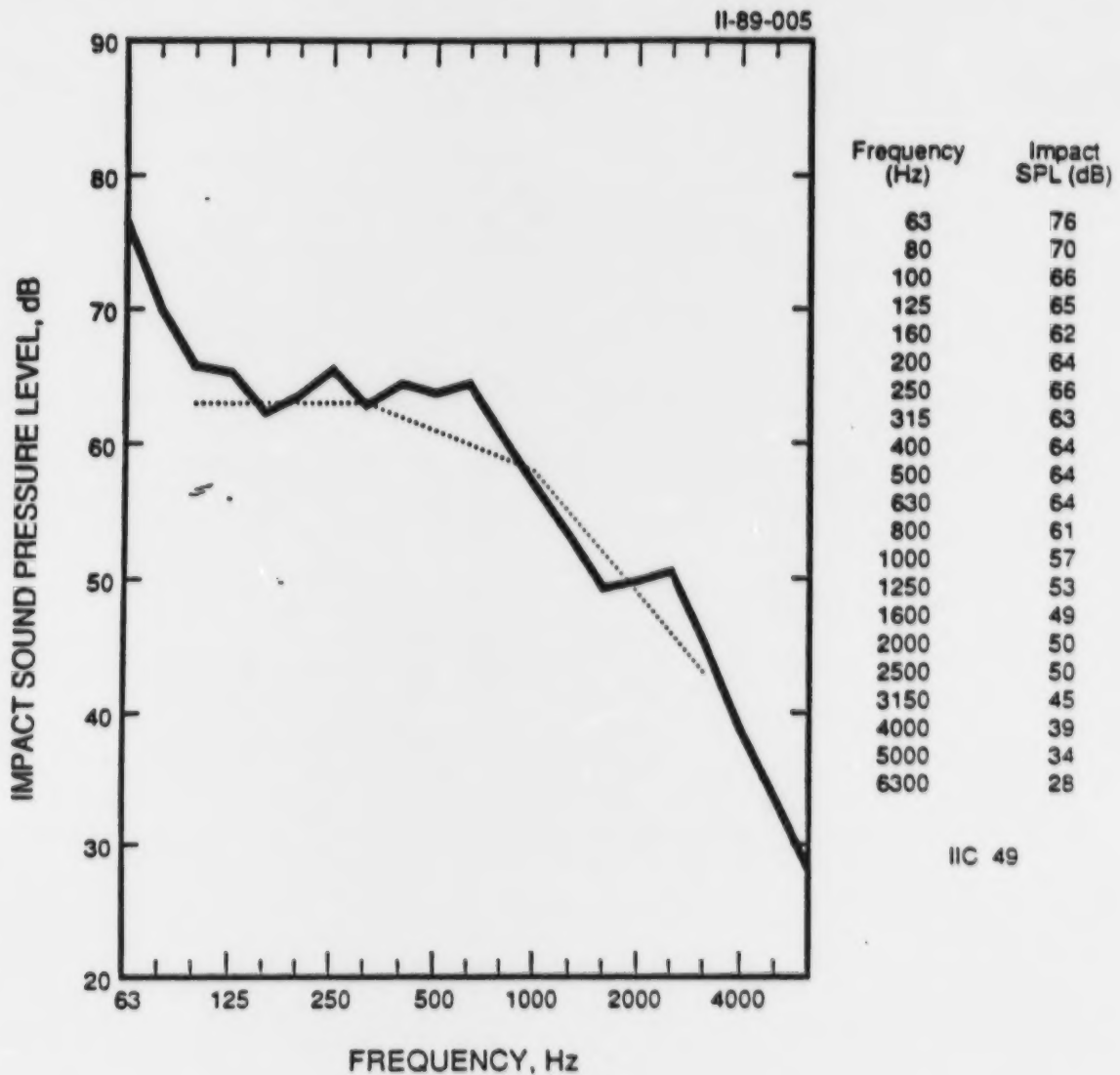
Floor 2: II-89-012

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 2 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



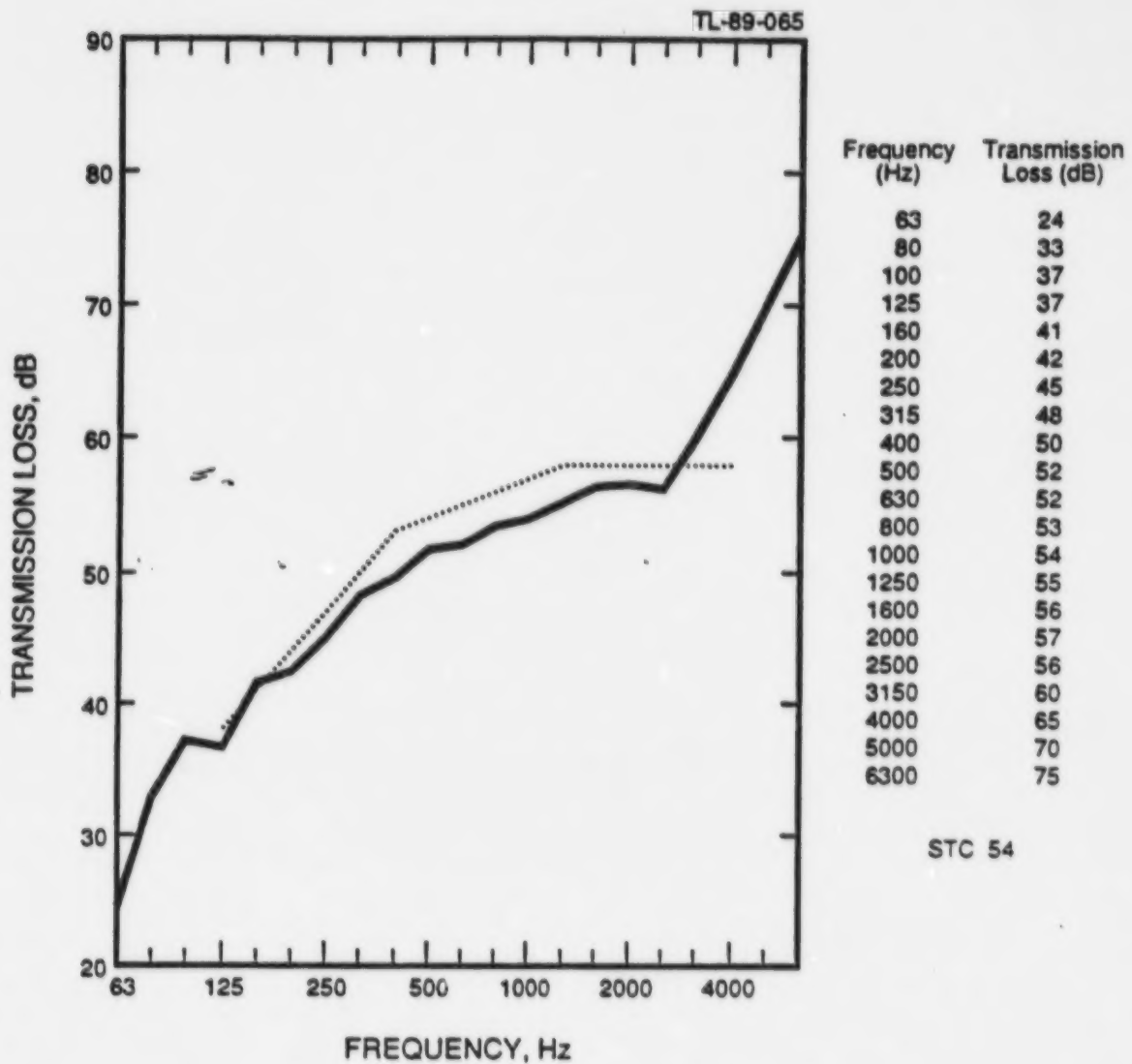
Floor 3: TL-89-064

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



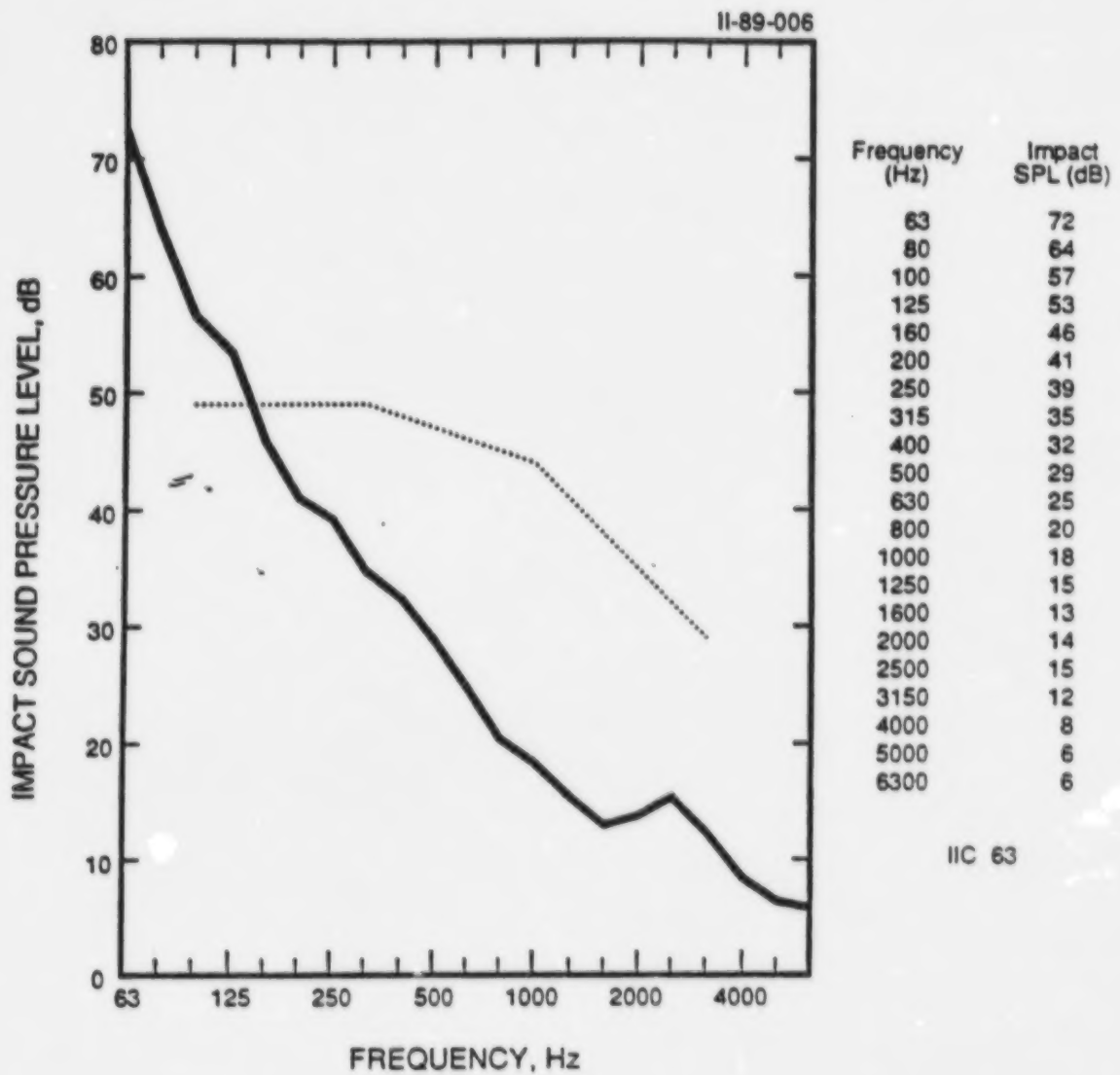
Floor 3: II-89-005

- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



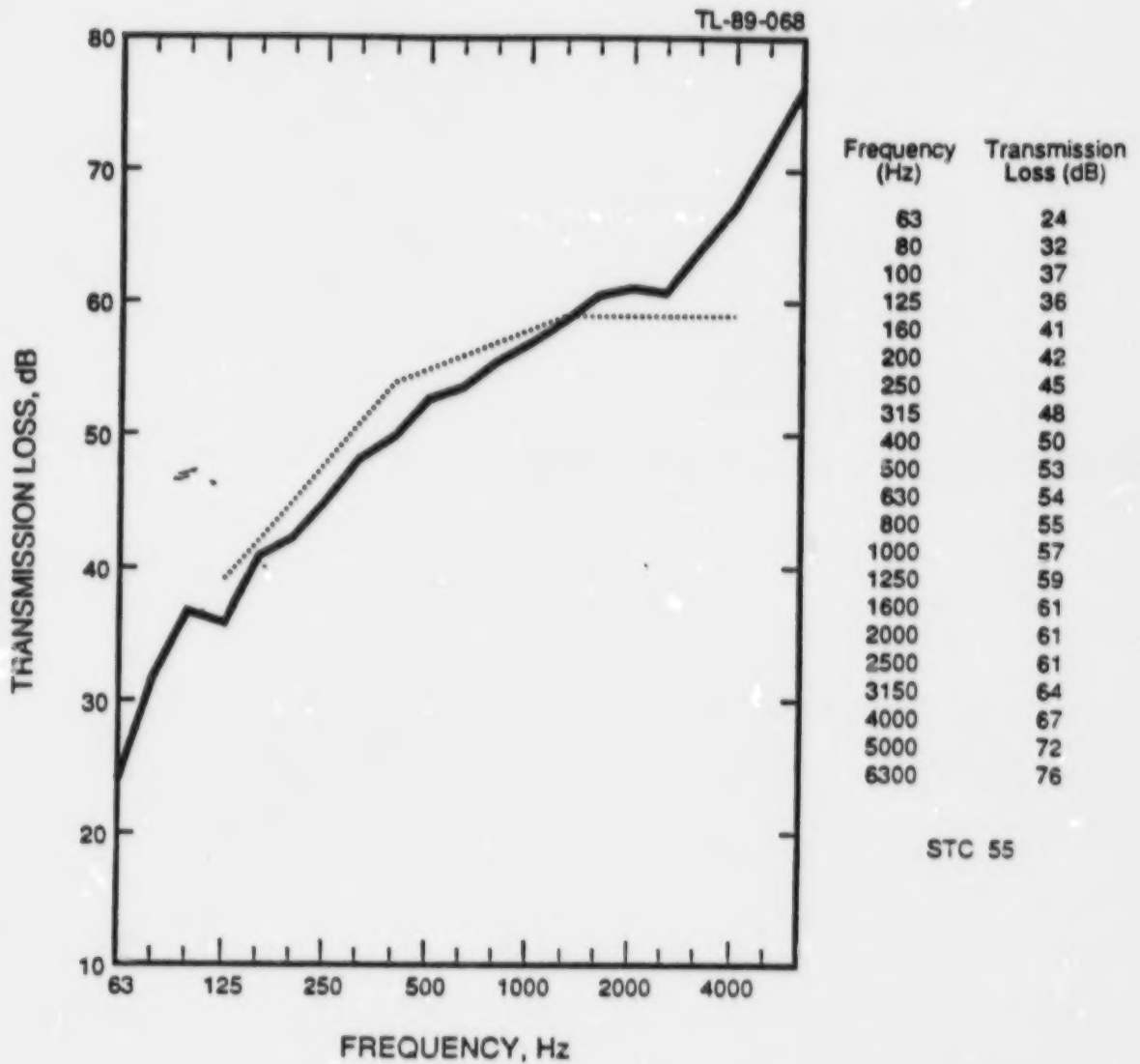
Floor 4: TL-89-065

- Grey carpet
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



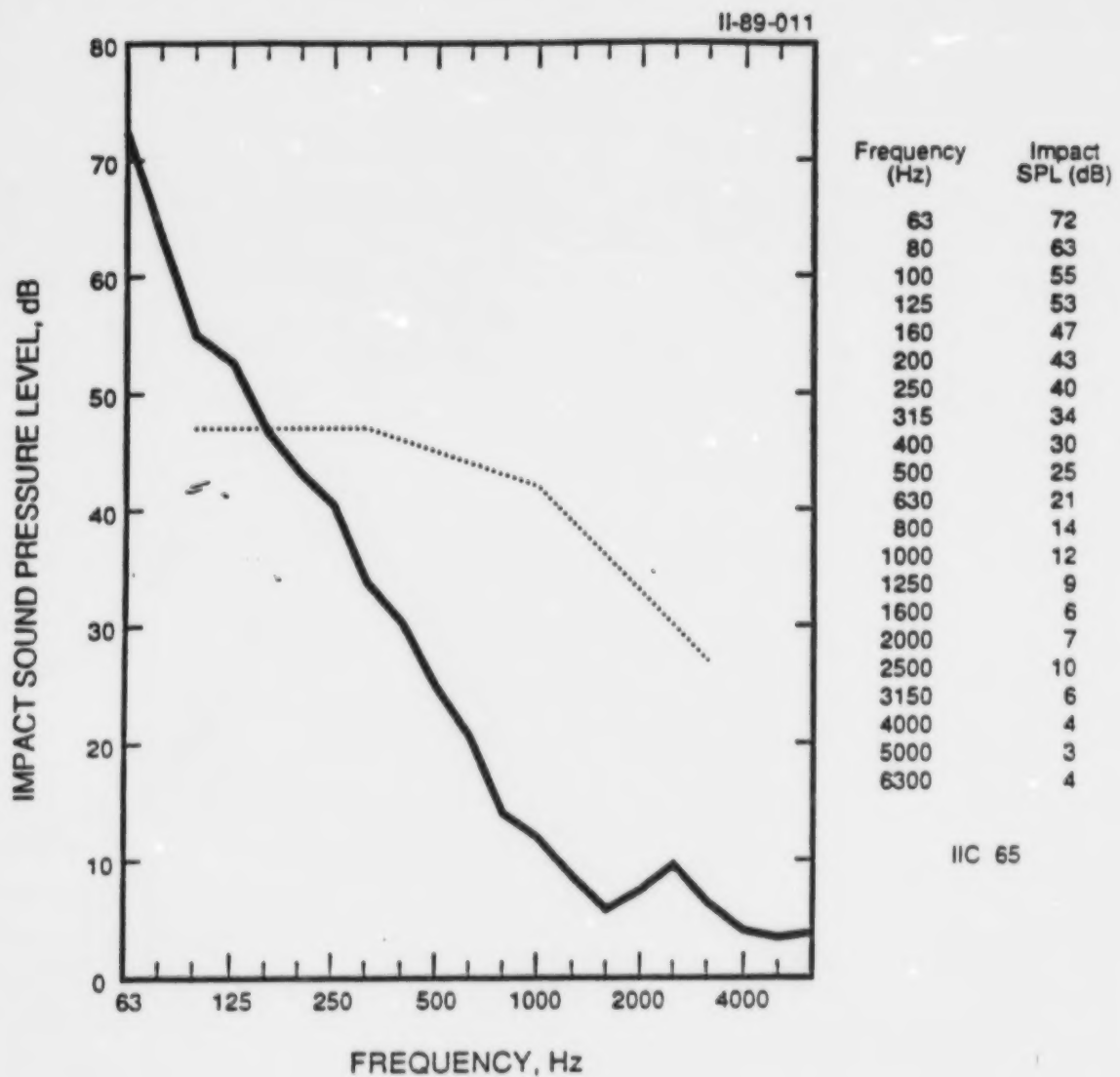
Floor 4: II-89-006

- Grey carpet
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



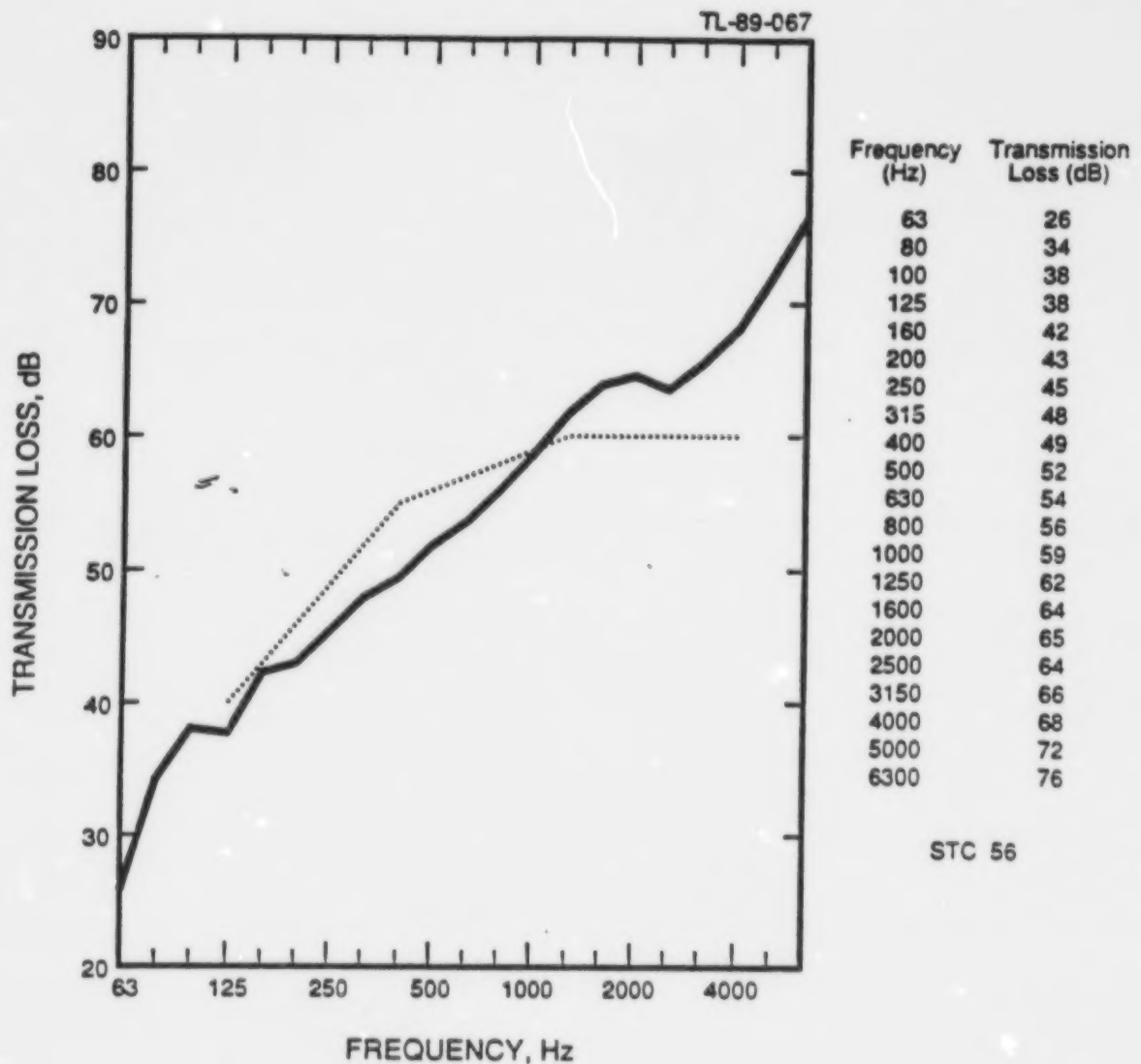
Floor 5: TL-89-068

- Brown foam-backed carpet
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



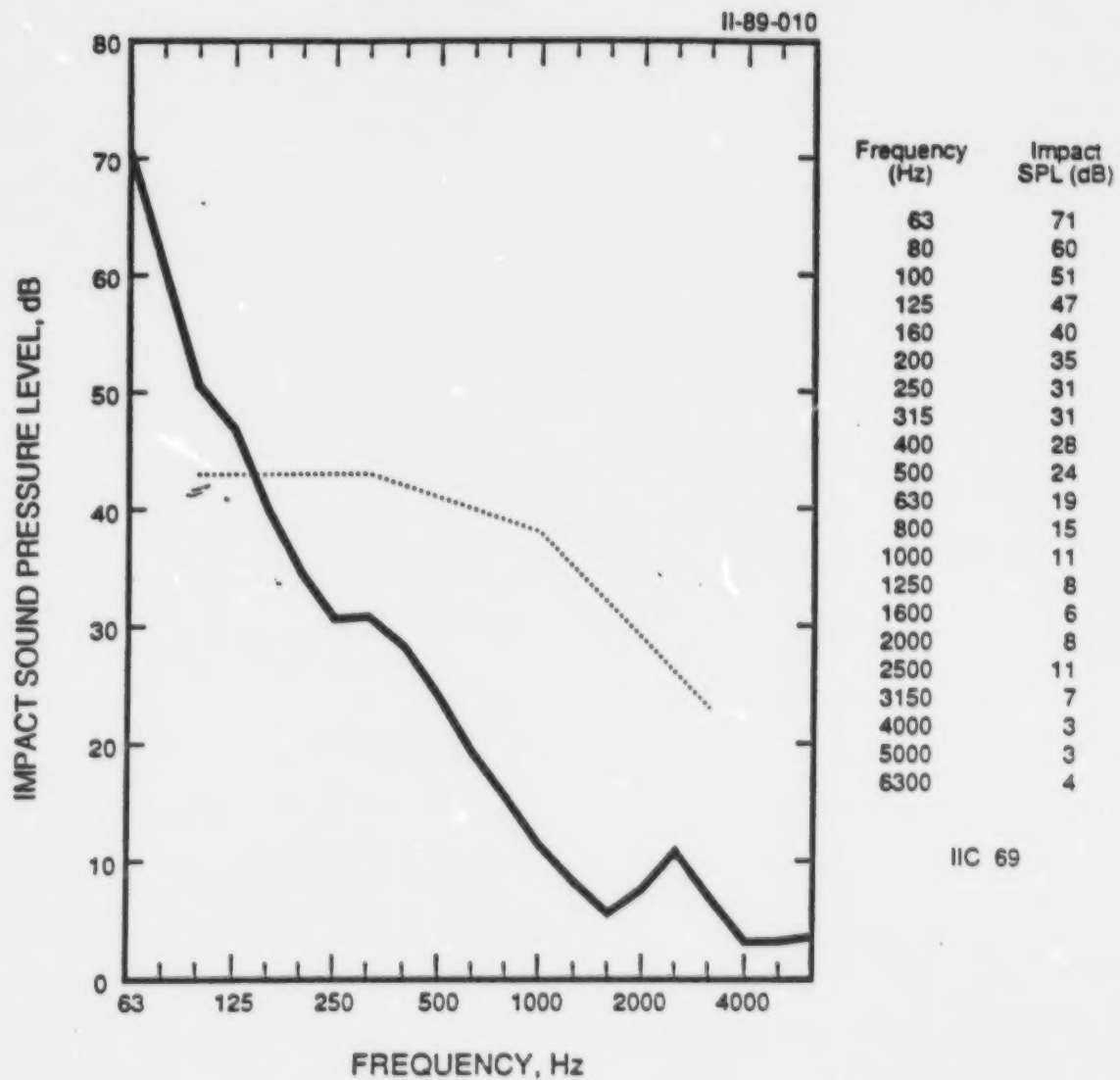
Floor 5: II-89-011

- Brown foam-backed carpet
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



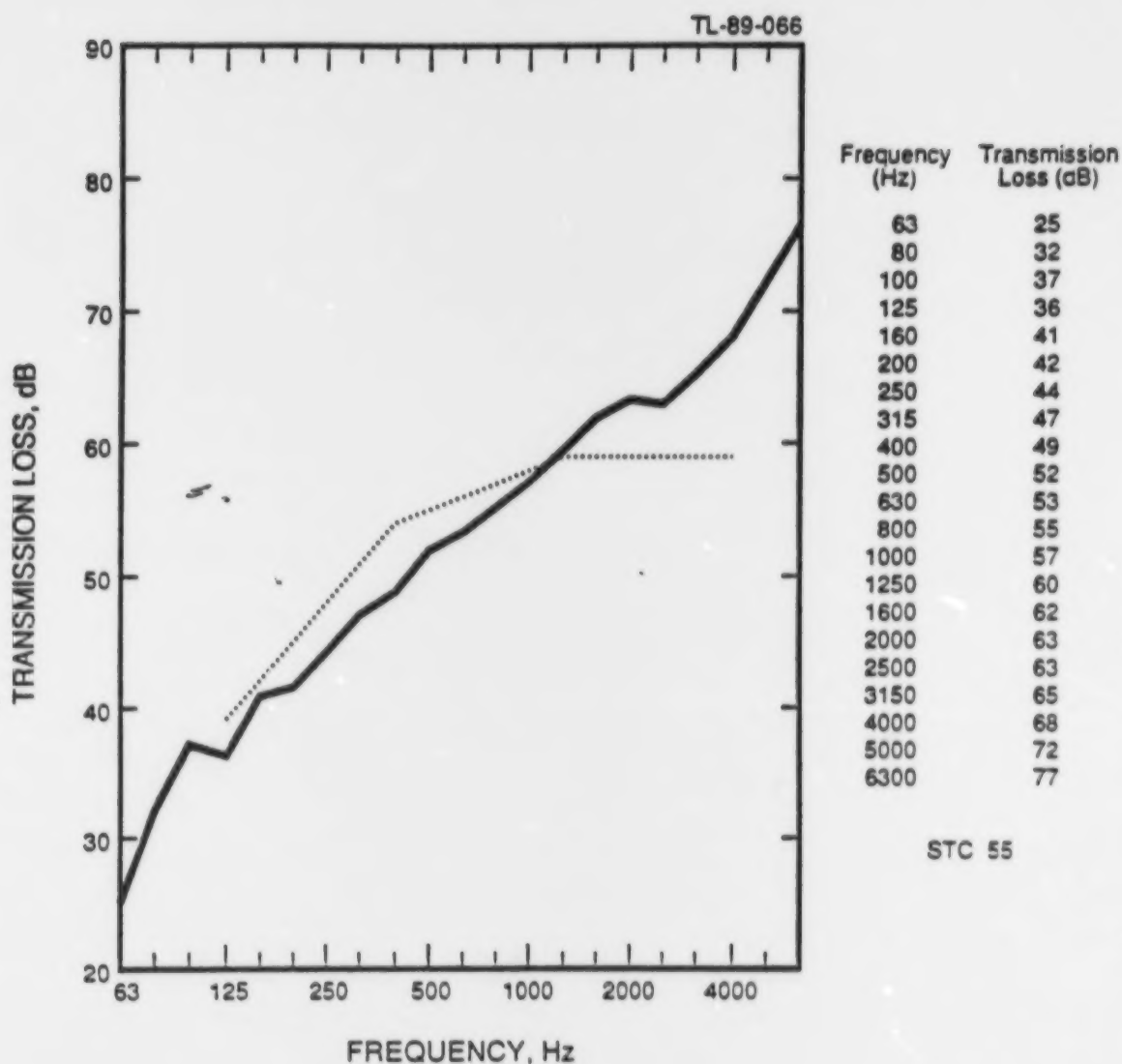
Floor 6: TL-89-067

- Grey carpet
- 6 mm felt underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



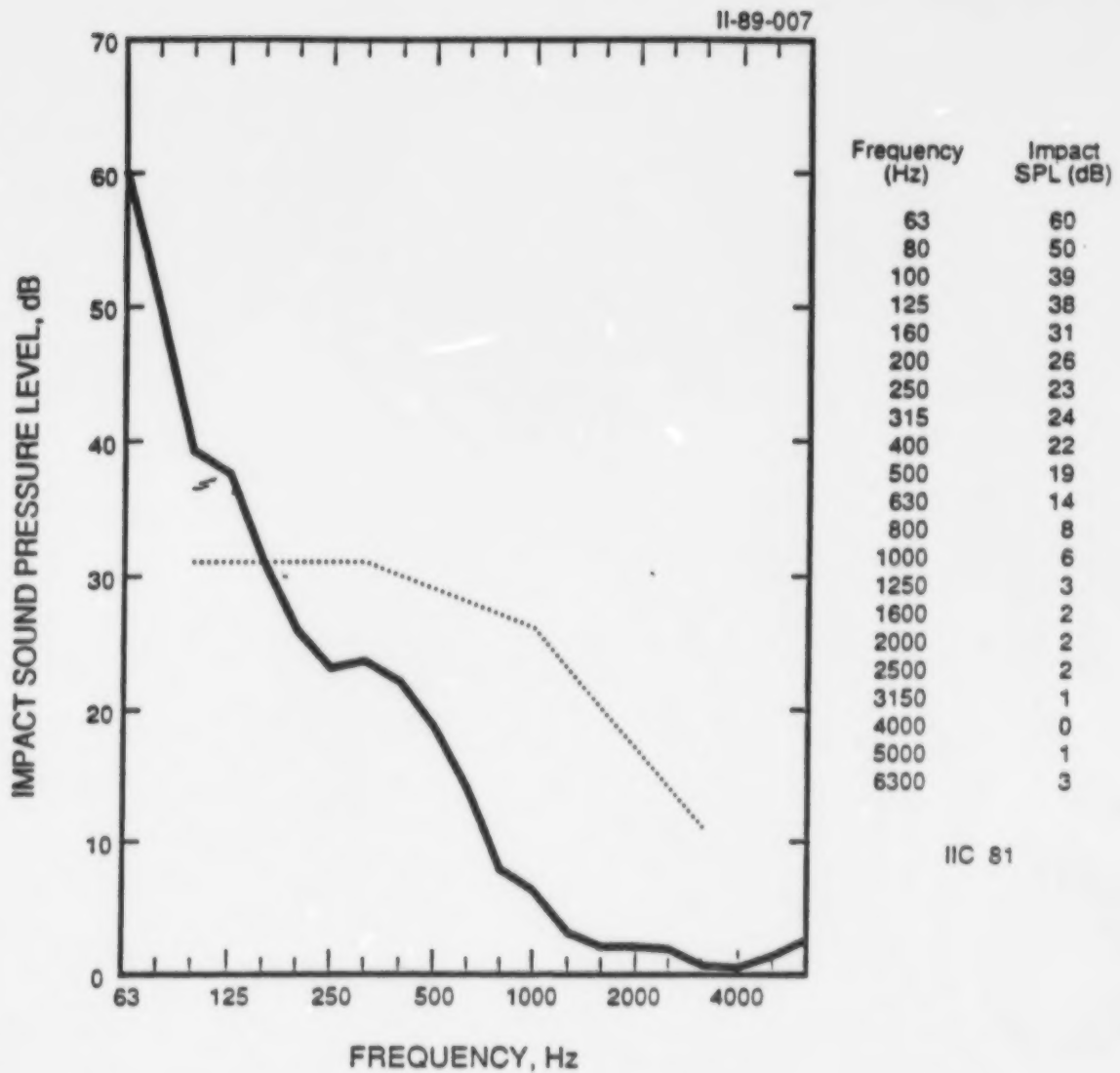
Floor 6: II-89-010

- Grey carpet
- 6 mm felt underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



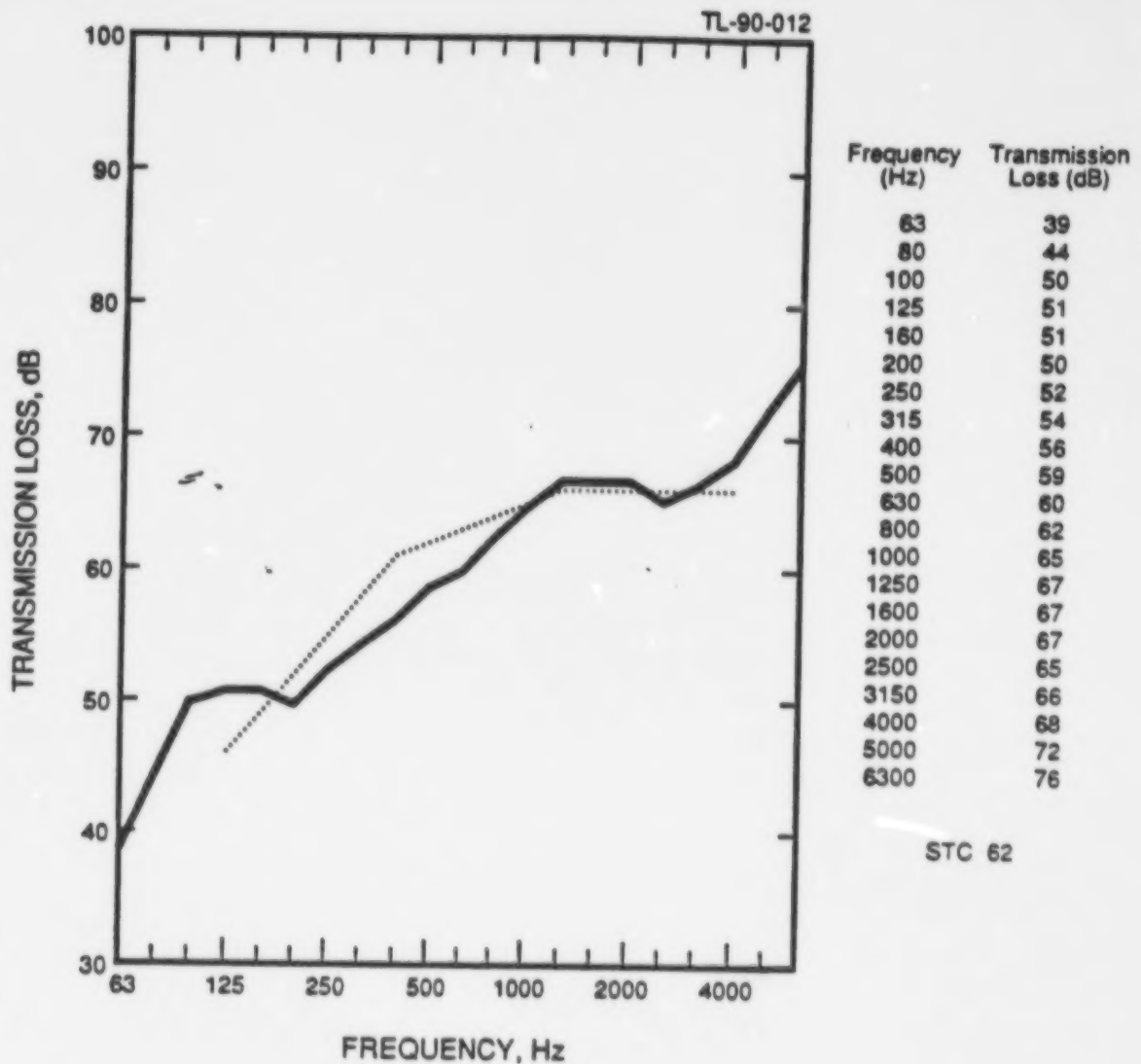
Floor 7: TL-89-066

- Grey carpet
- 9 mm foam carpet underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



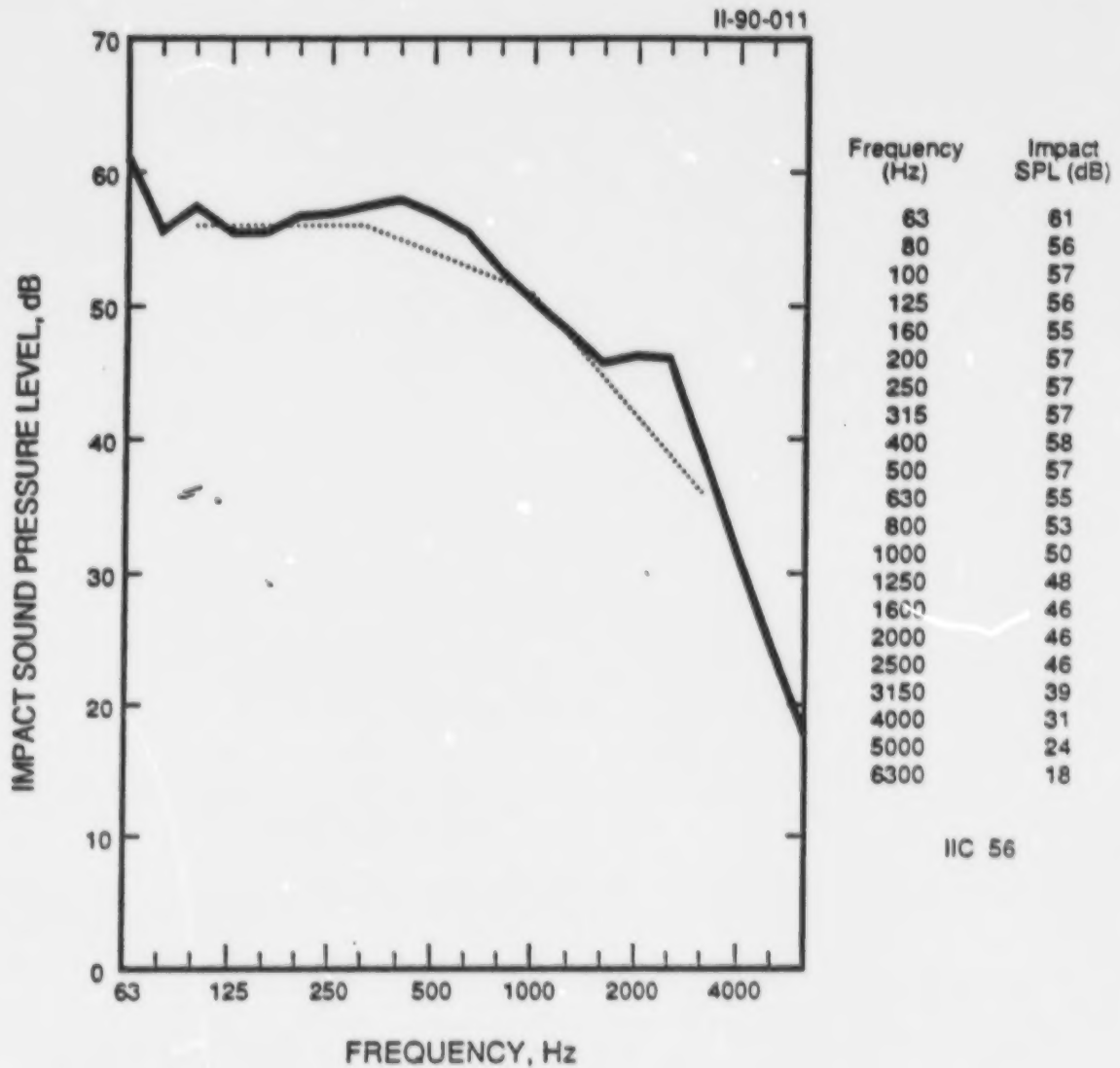
Floor 7: II-89-007

- Grey carpet
- 9 mm foam carpet underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



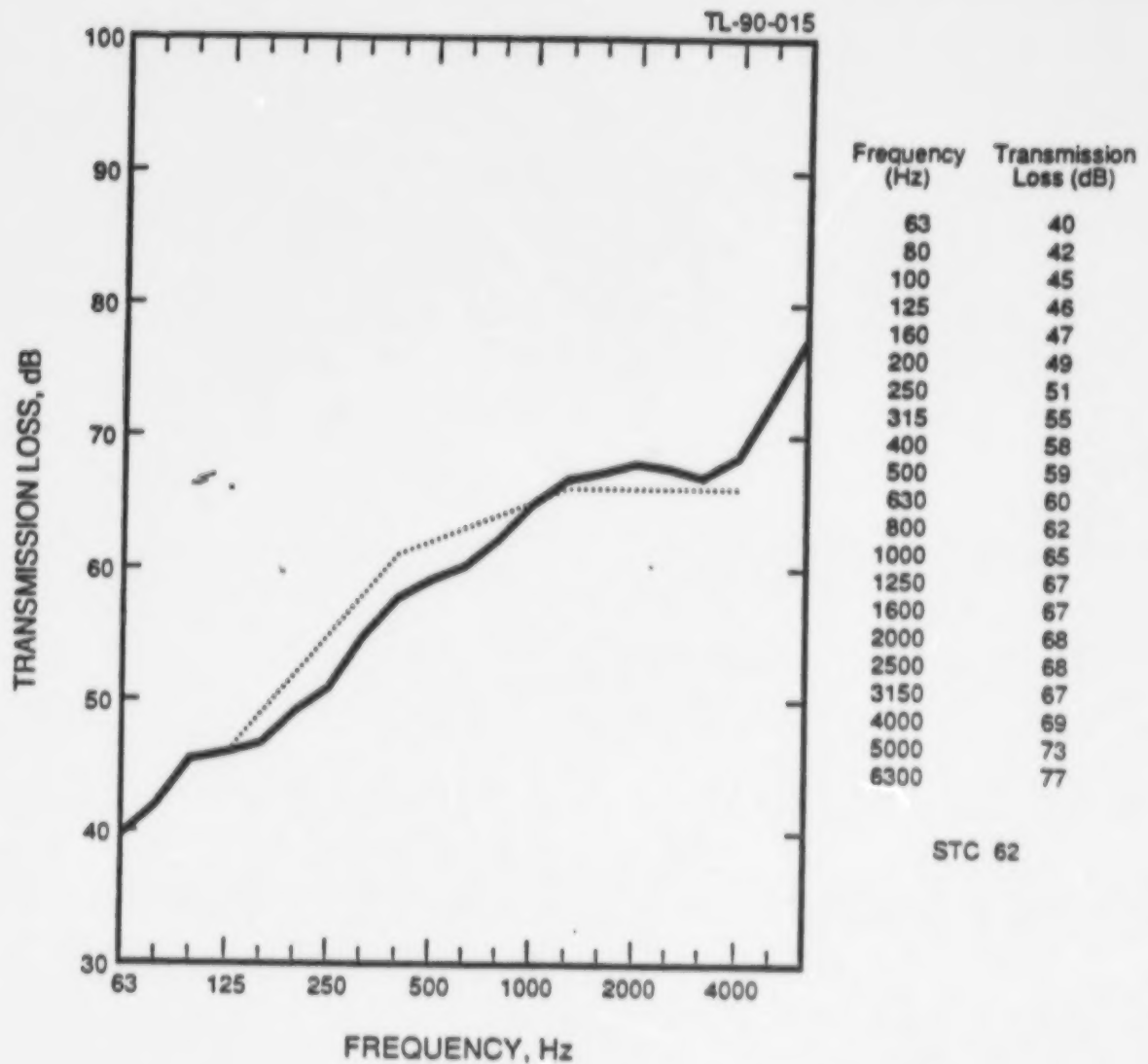
Floor 8: TL-90-012

- 2 layers of 6 mm Wonderboard laminated together
- 3 mm closed cell neoprene foam
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



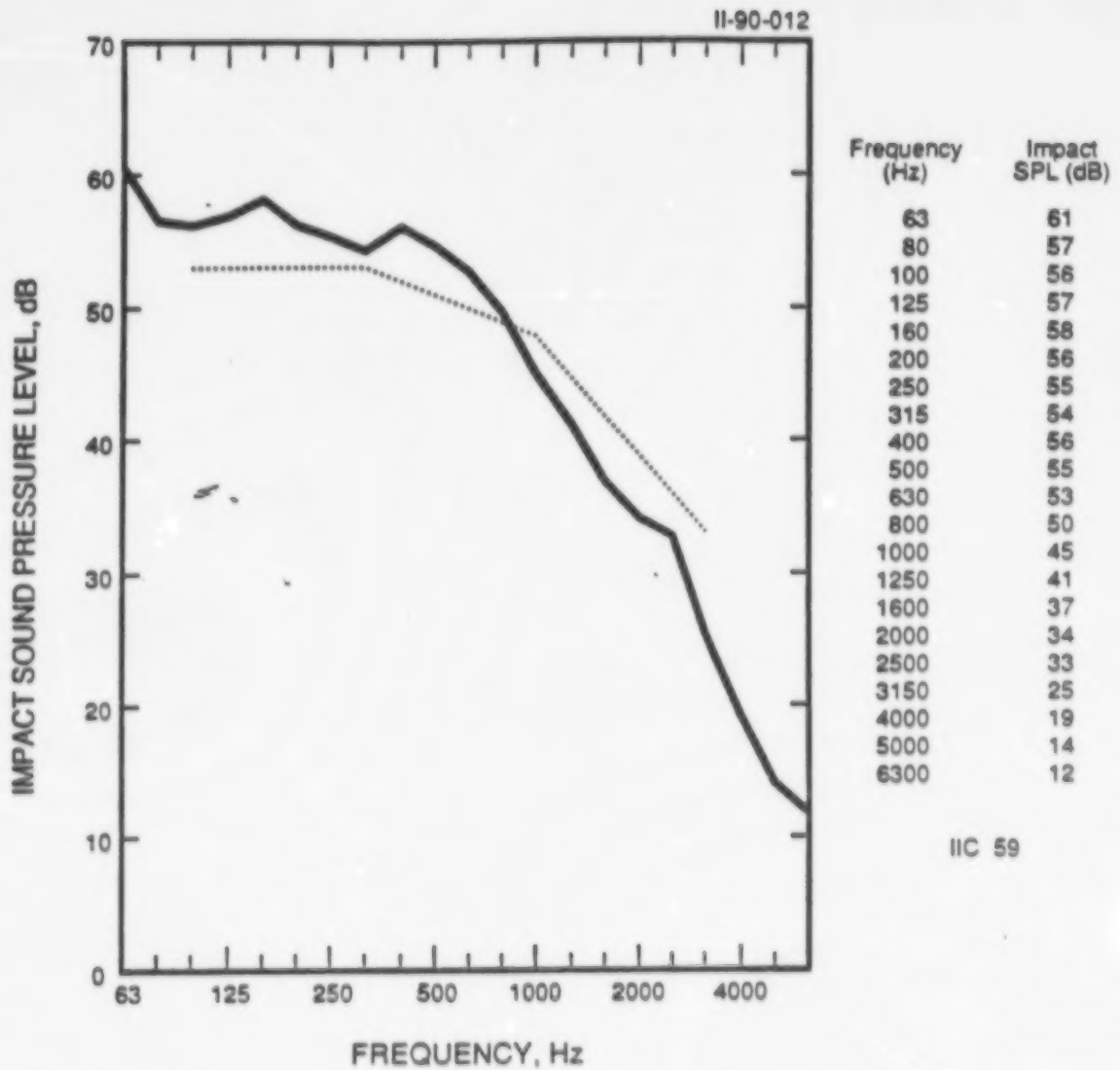
Floor 8: II-90-011

- 2 layers of 6 mm Wonderboard laminated together
- 3 mm closed cell neoprene foam
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



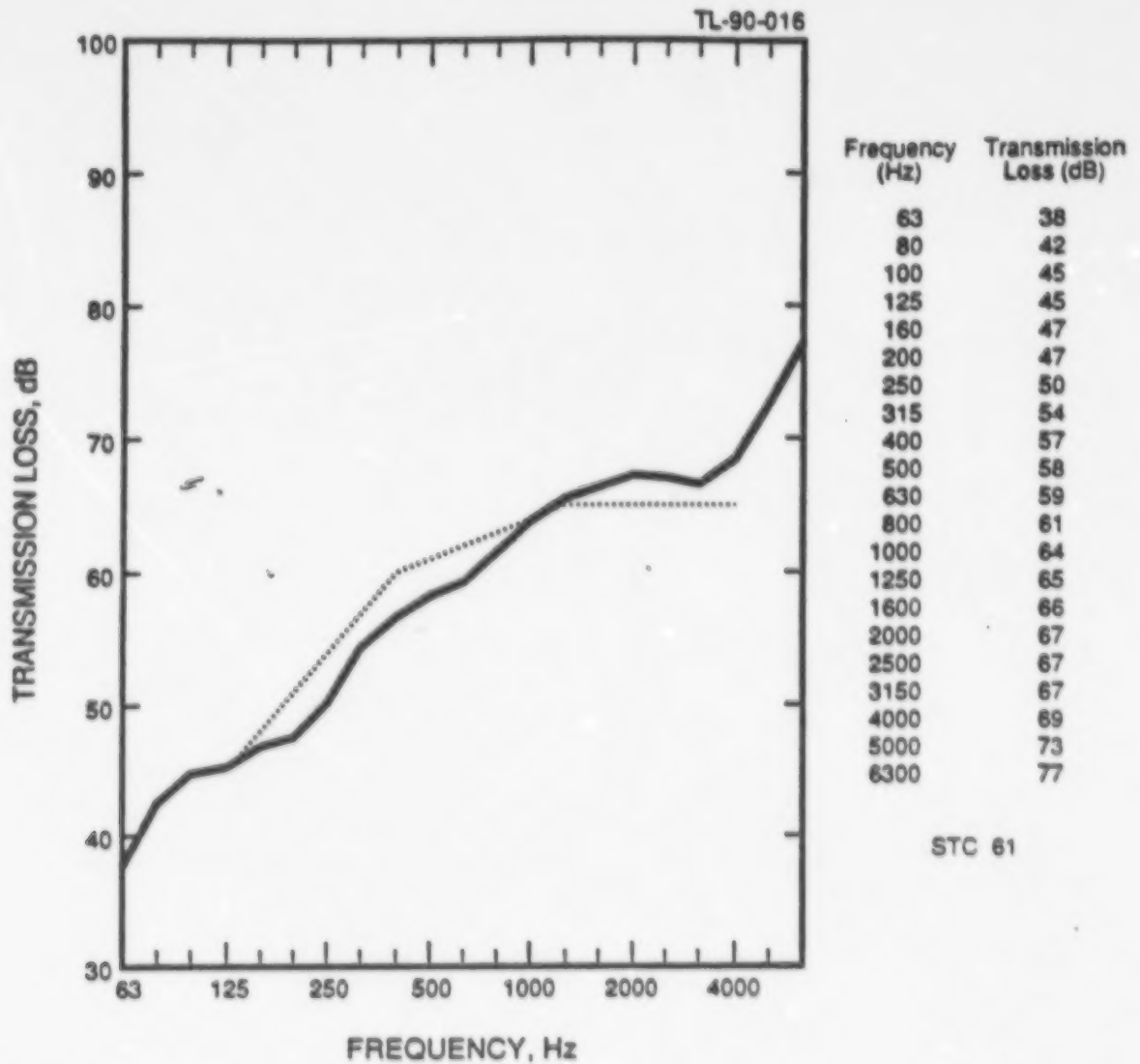
Floor 9: TL-90-015

- 2 layers of 6 mm Wonderboard laminated together
- 9 mm foam carpet underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



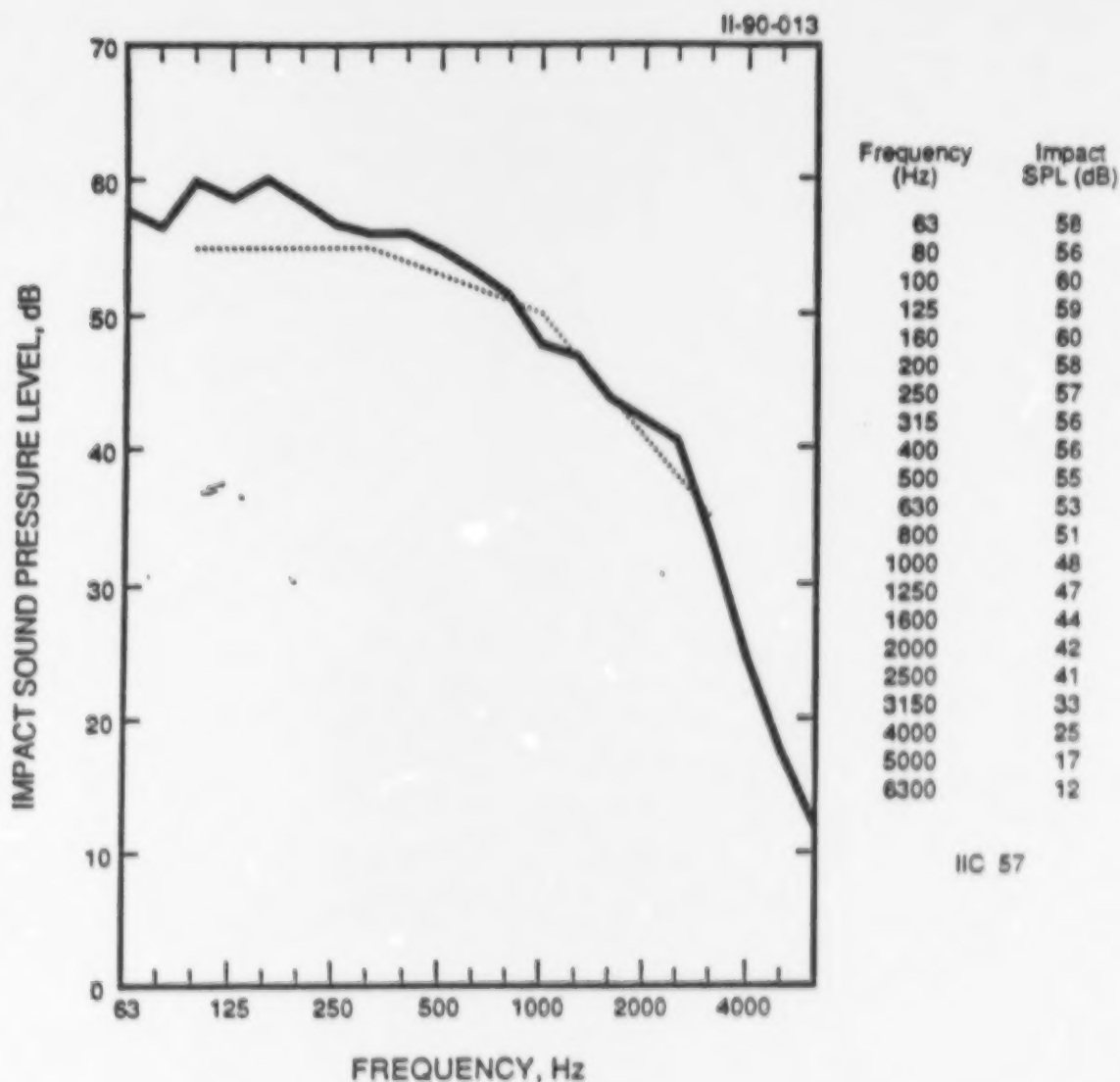
Floor 9: II-90-012

- 2 layers of 6 mm Wonderboard laminated together
- 9 mm foam carpet underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



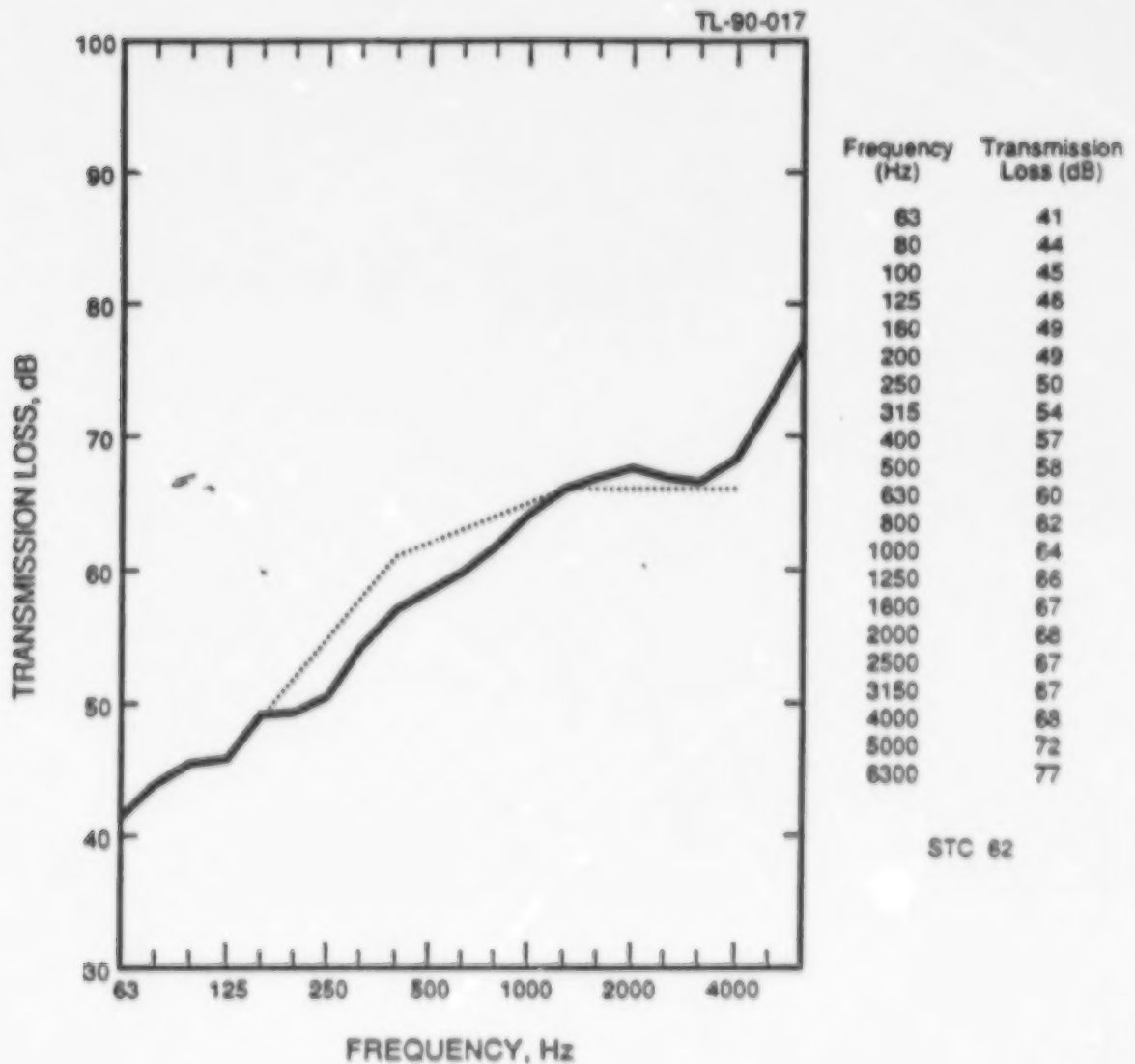
Floor 10: TL-90-016

- 2 layers of 5 mm Wonderboard laminated together
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



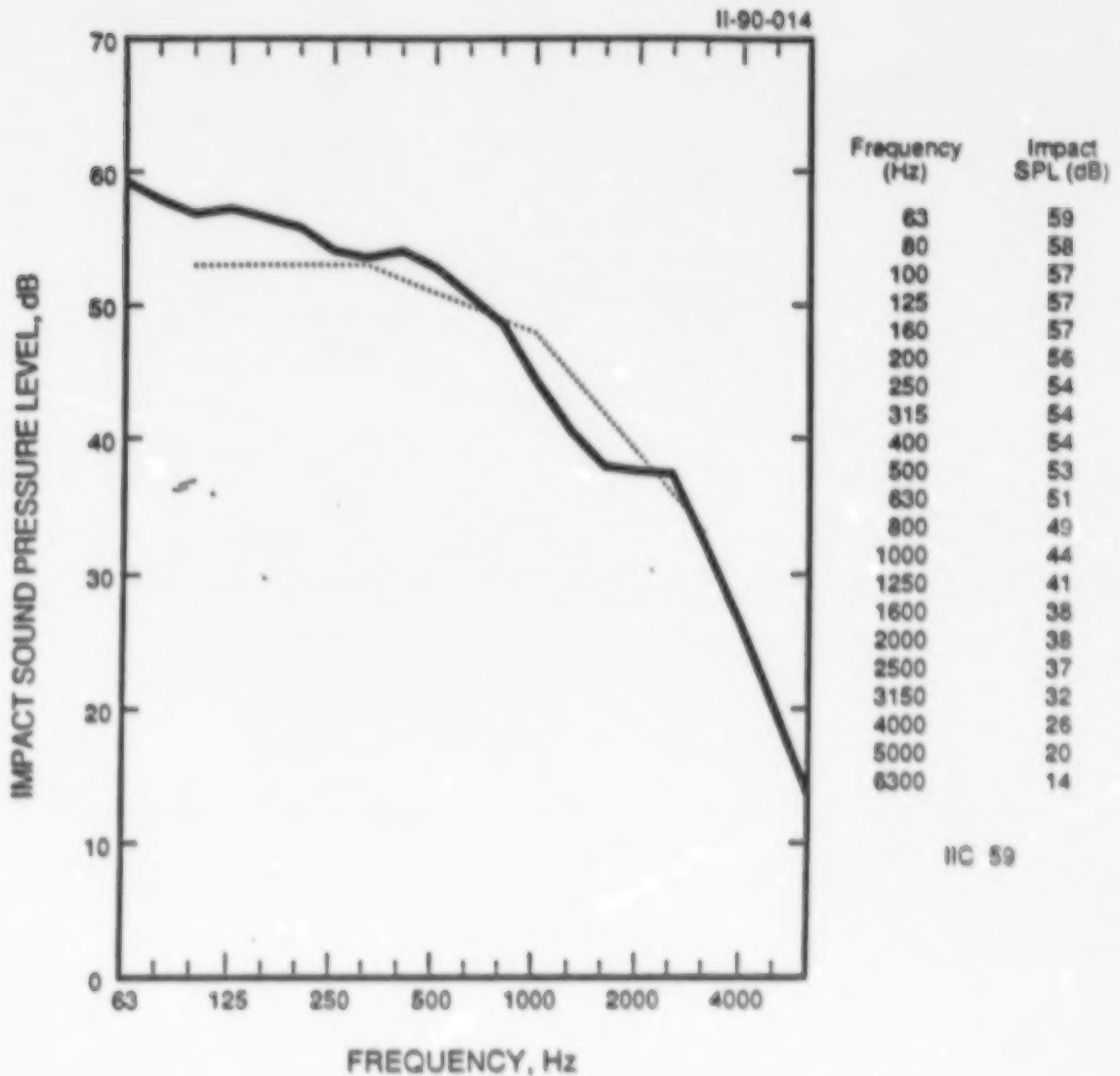
Floor 10: II-90-013

- 2 layers of 6 mm Wonderboard laminated together
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



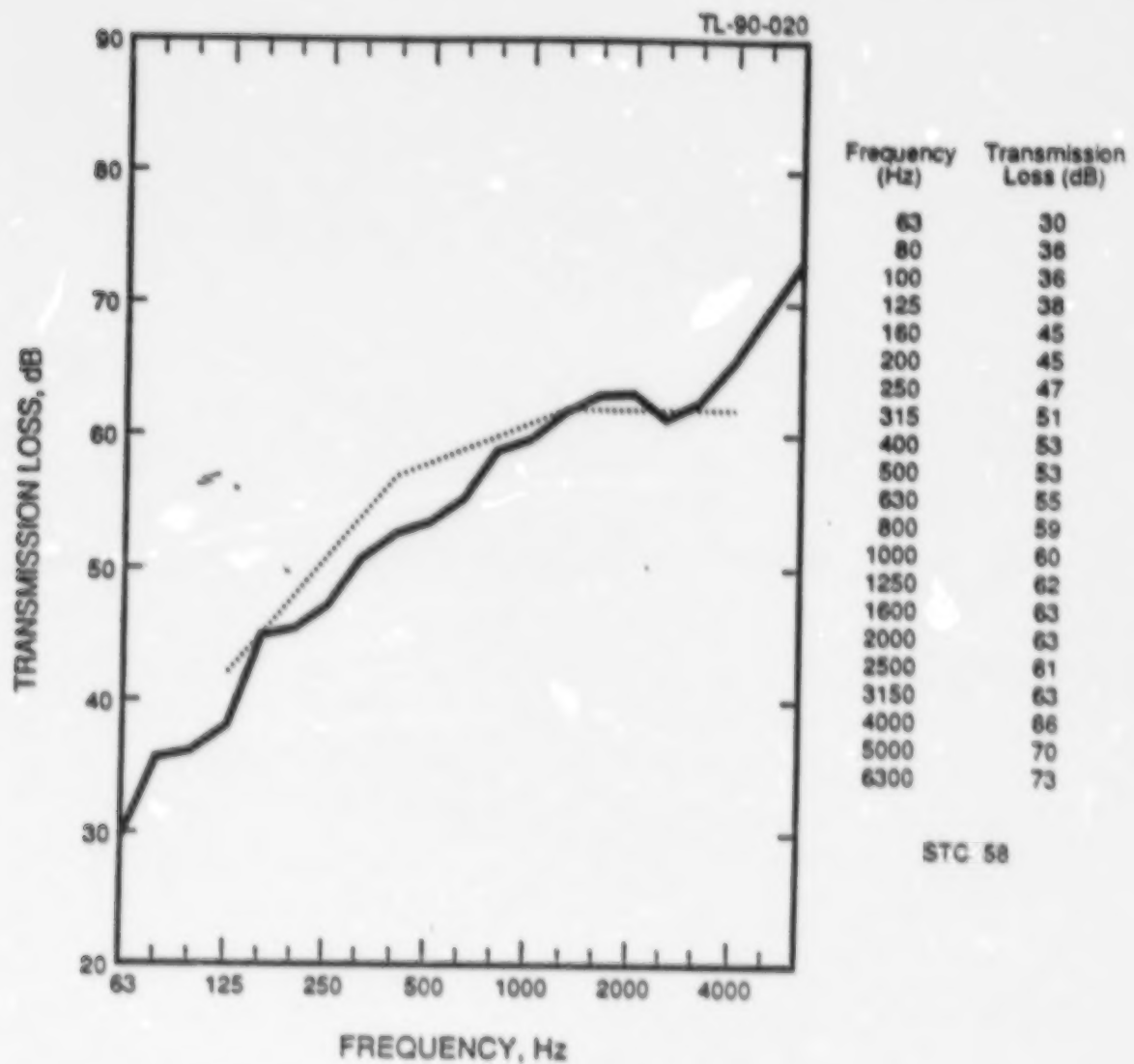
Floor 11: TL-90-017

- 2 layers of 6 mm Wonderboard laminated together
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm panels of rigid glass fibre between furring strips
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



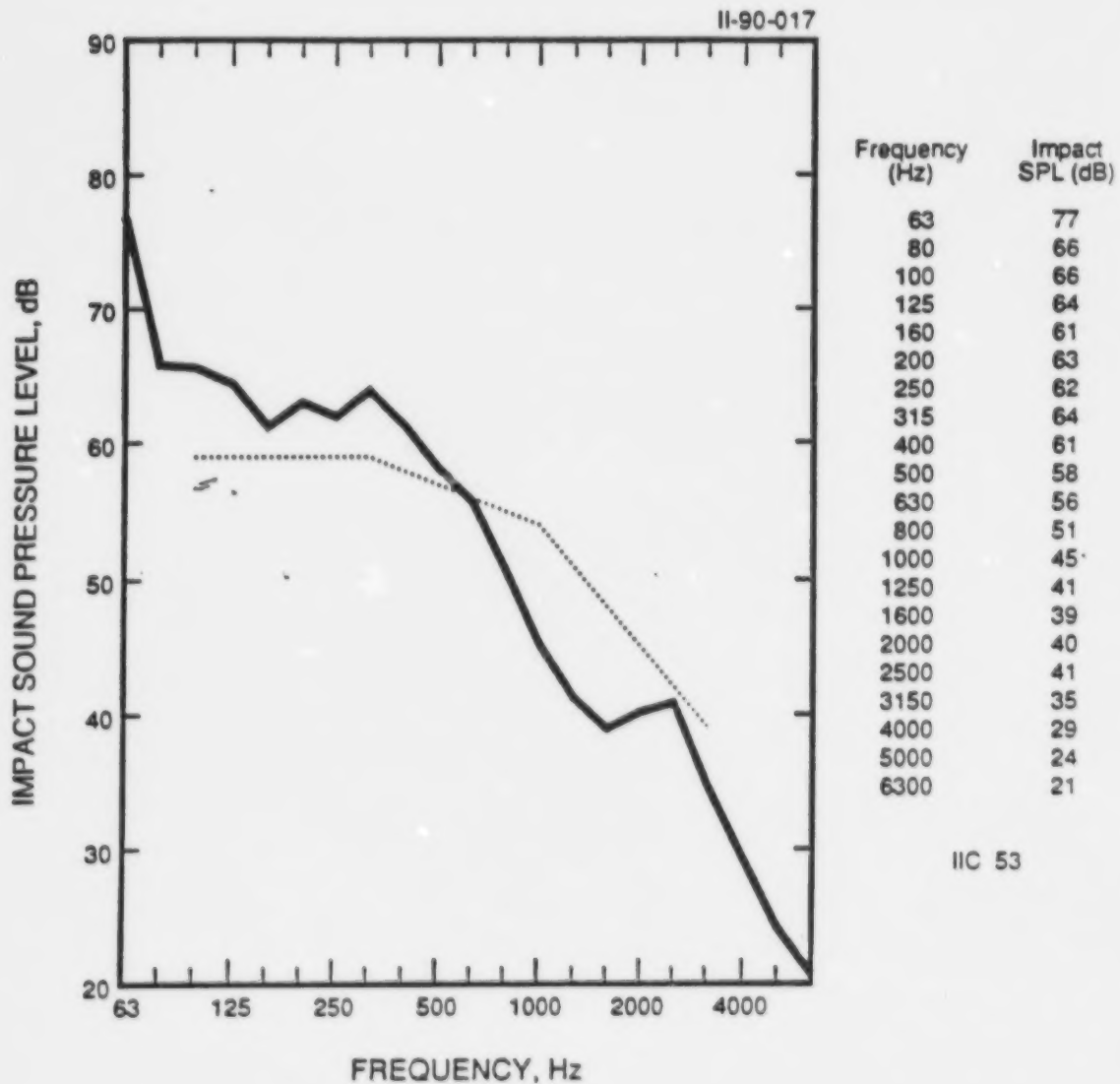
Floor 11: II-90-014

- 2 layers of 6 mm Wonderboard laminated together
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm panels of rigid glass fibre between furring strips
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



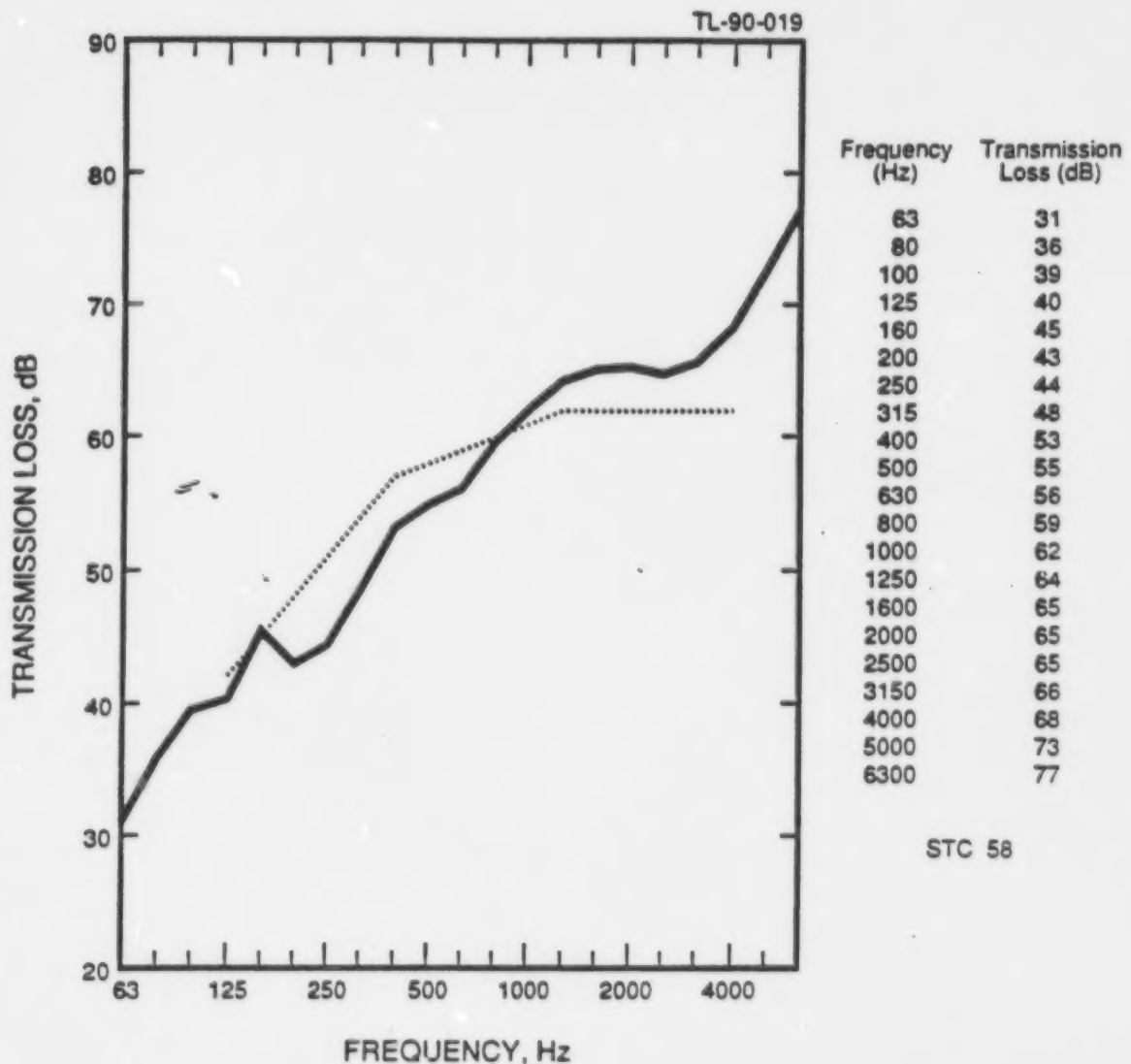
Floor 12: TL-90-020

- 16 mm tongue and groove plywood
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



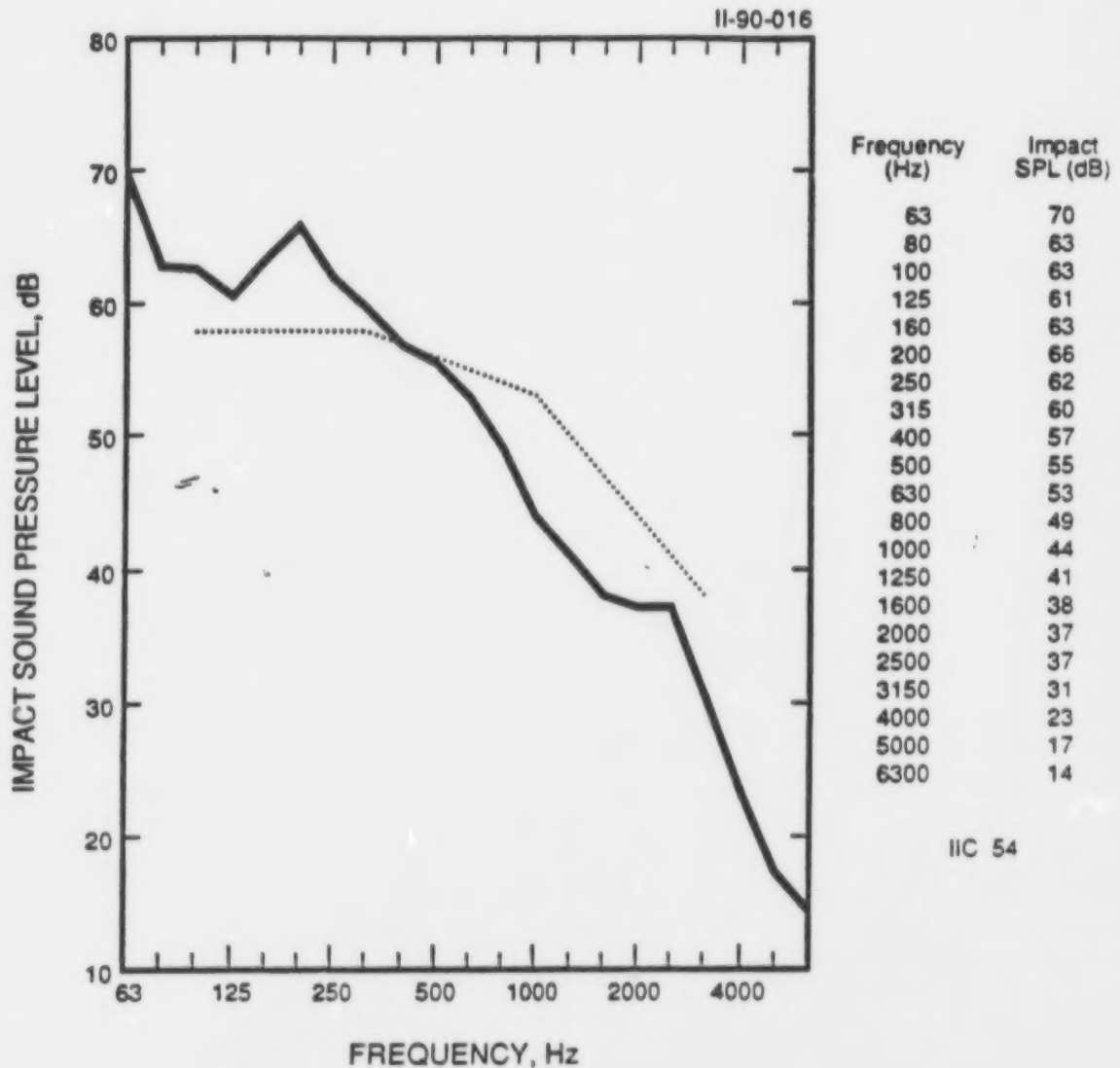
Floor 12: II-90-017

- 16 mm tongue and groove plywood
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



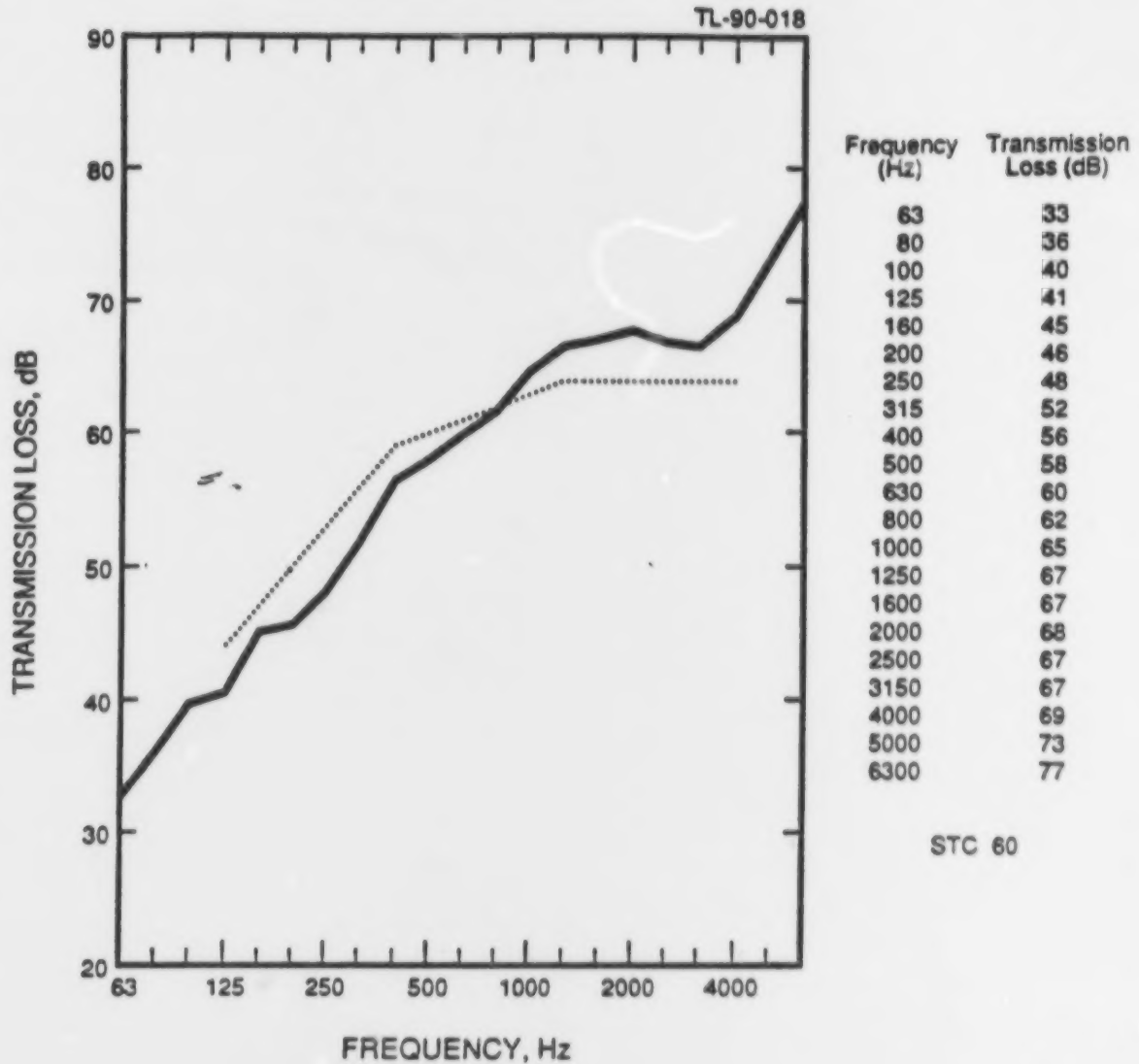
Floor 13: TL-90-019

- 16 mm tongue and groove plywood
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



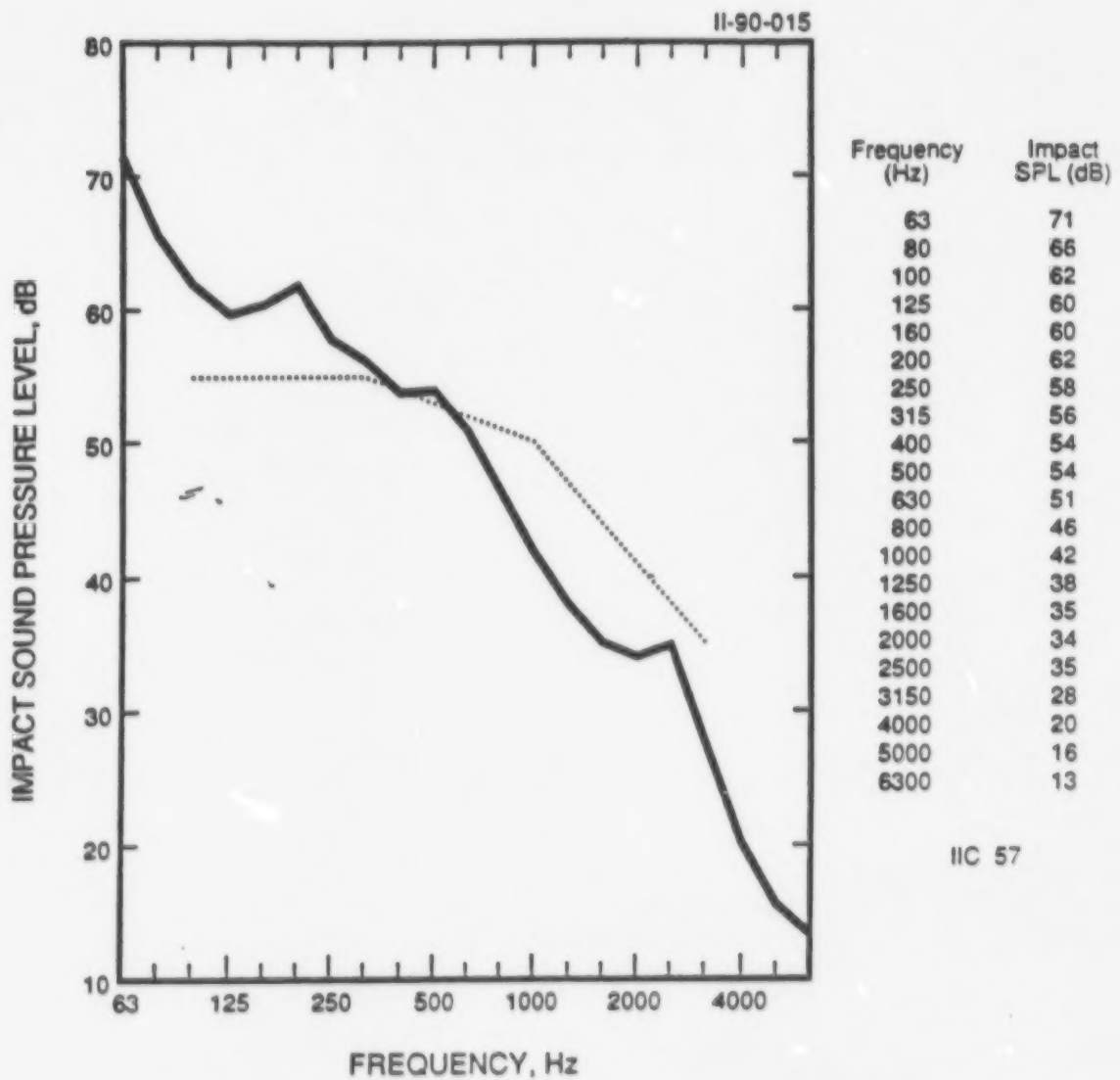
Floor 13: II-90-016

- 16 mm tongue and groove plywood
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



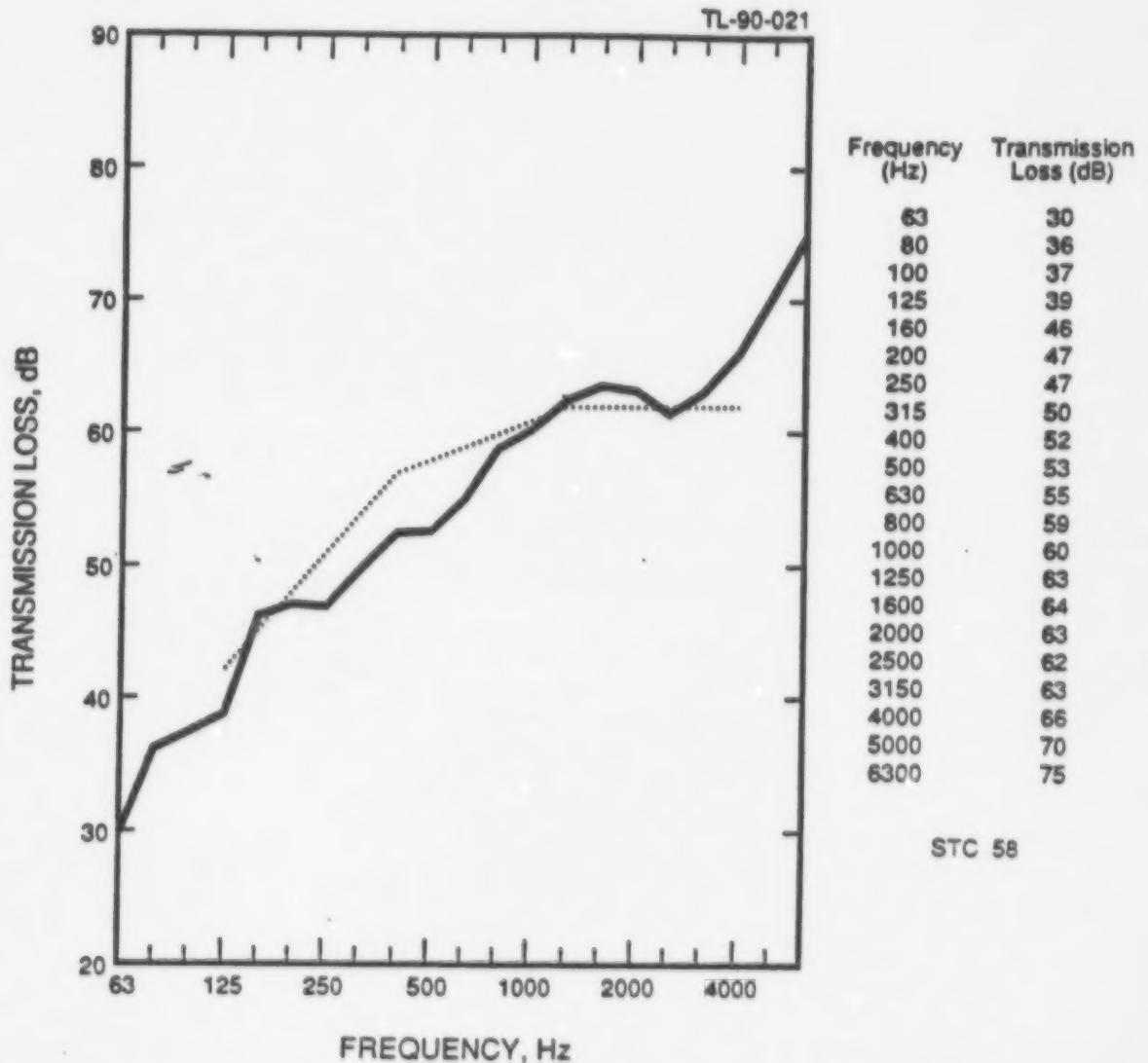
Floor 14: TL-90-018

- 16 mm tongue and groove plywood
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm panels of rigid glass fibre between furring strips
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



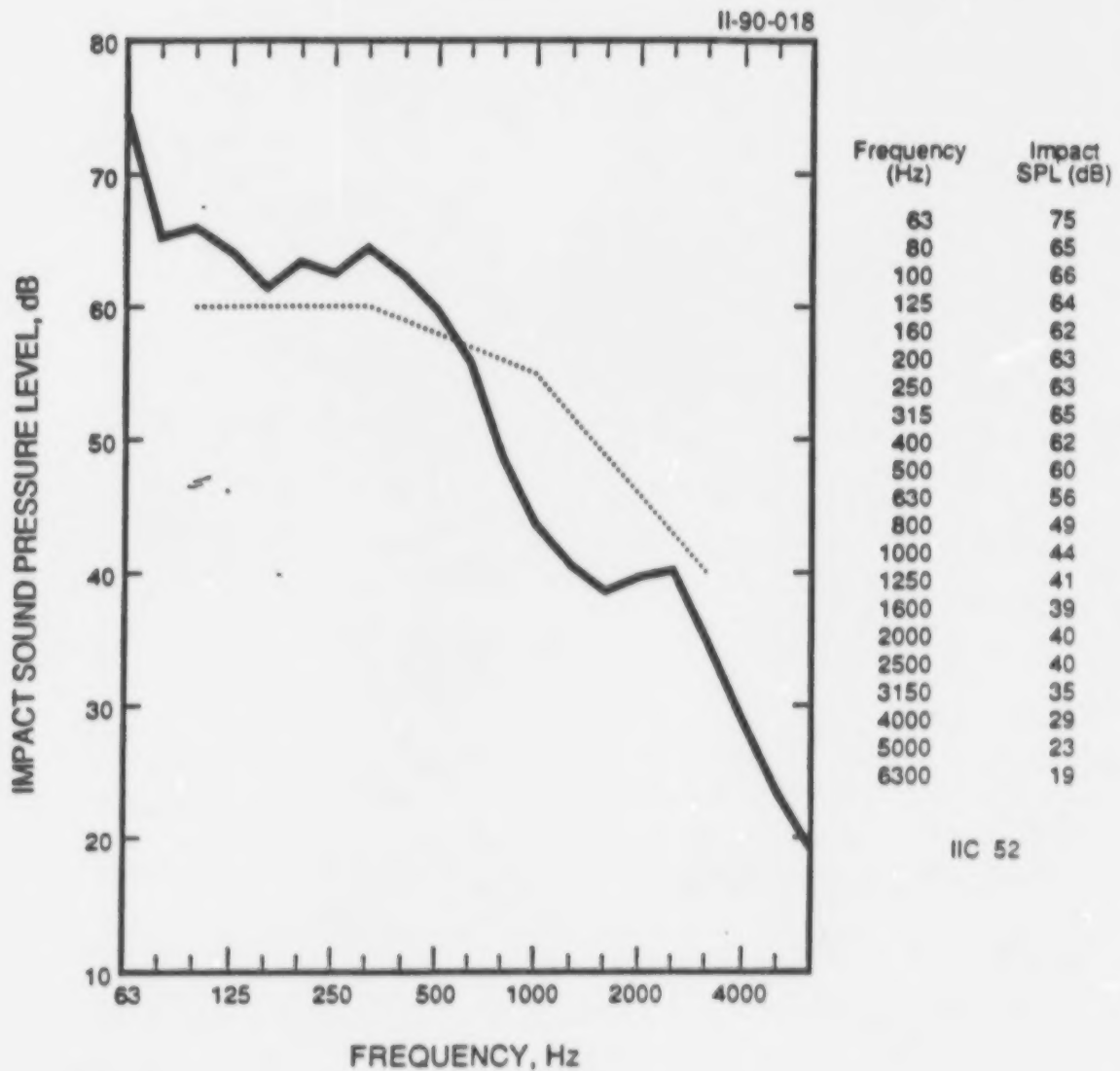
Floor 14: II-90-015

- 16 mm tongue and groove plywood
- 16 x 70 mm wood furring strips with 3 mm closed cell neoprene foam attached to underside
- 16 mm panels of rigid glass fibre between furring strips
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



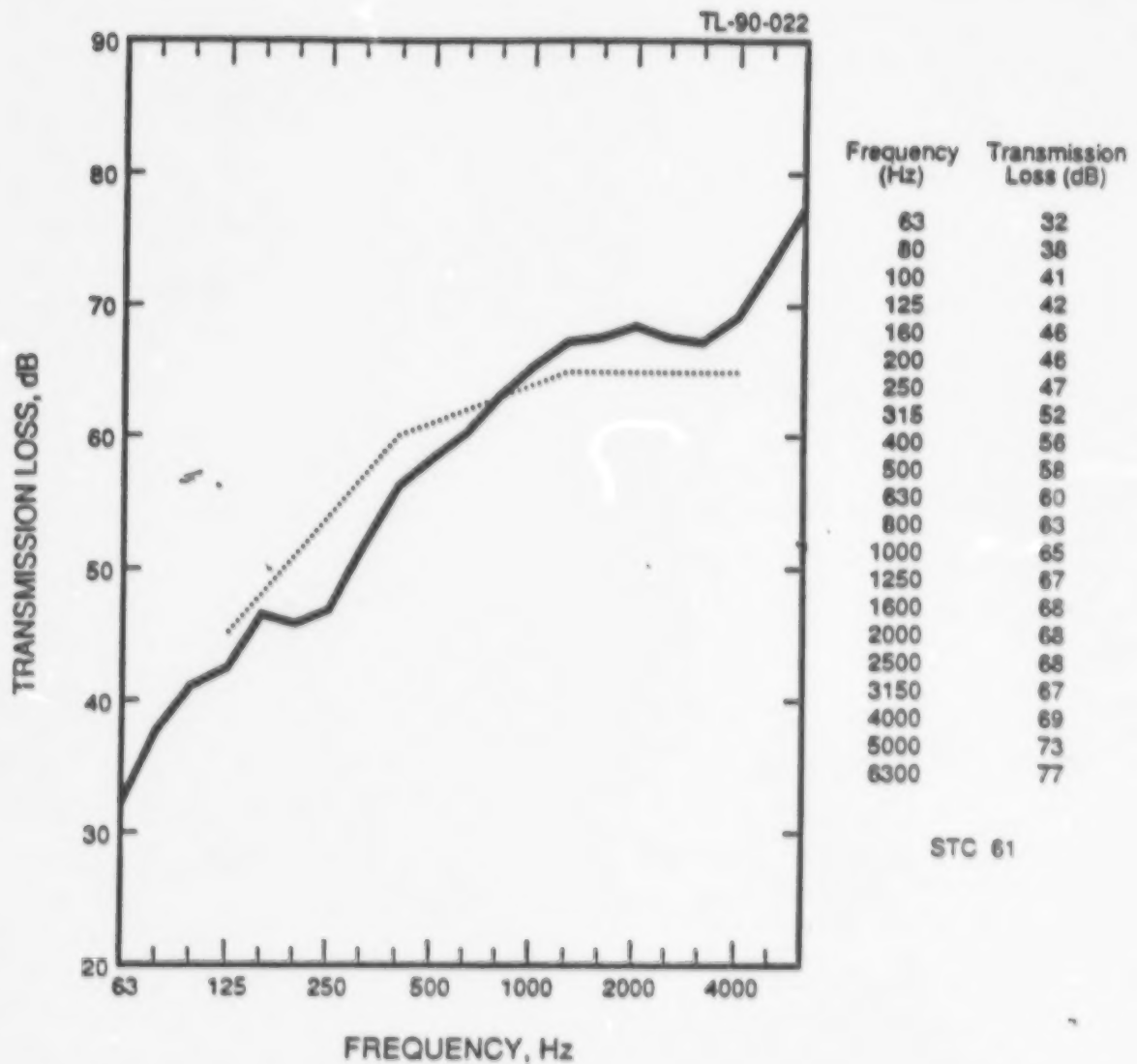
Floor 15: TL-90-021

- 16 mm tongue and groove plywood
- 1 mm thick saturated building paper
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



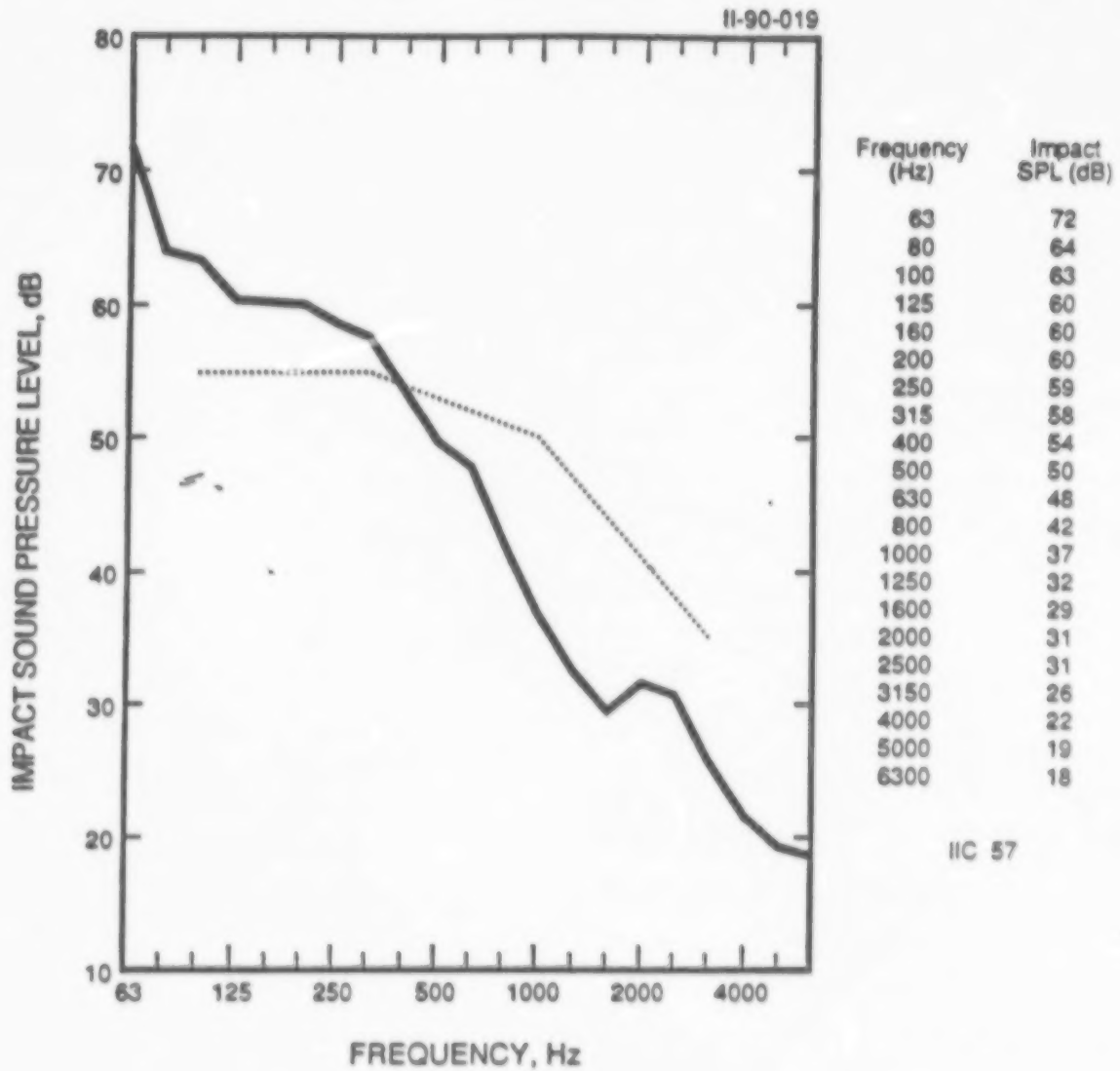
Floor 15: II-90-018

- 16 mm tongue and groove plywood
- 1 mm thick saturated building paper
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



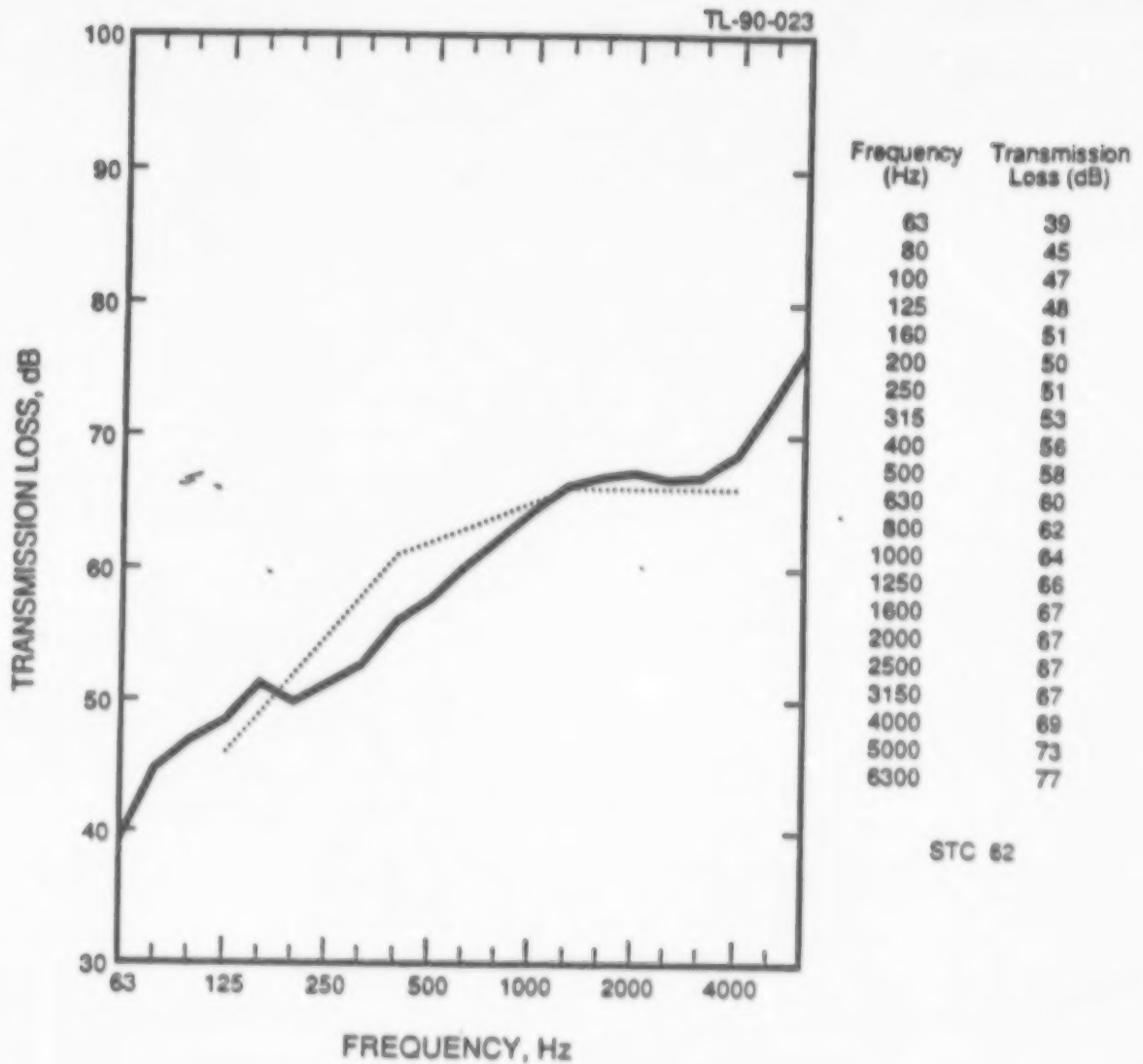
Floor 16: TL-90-022

- 16 mm tongue and groove plywood
- 11 mm wood fibre board
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



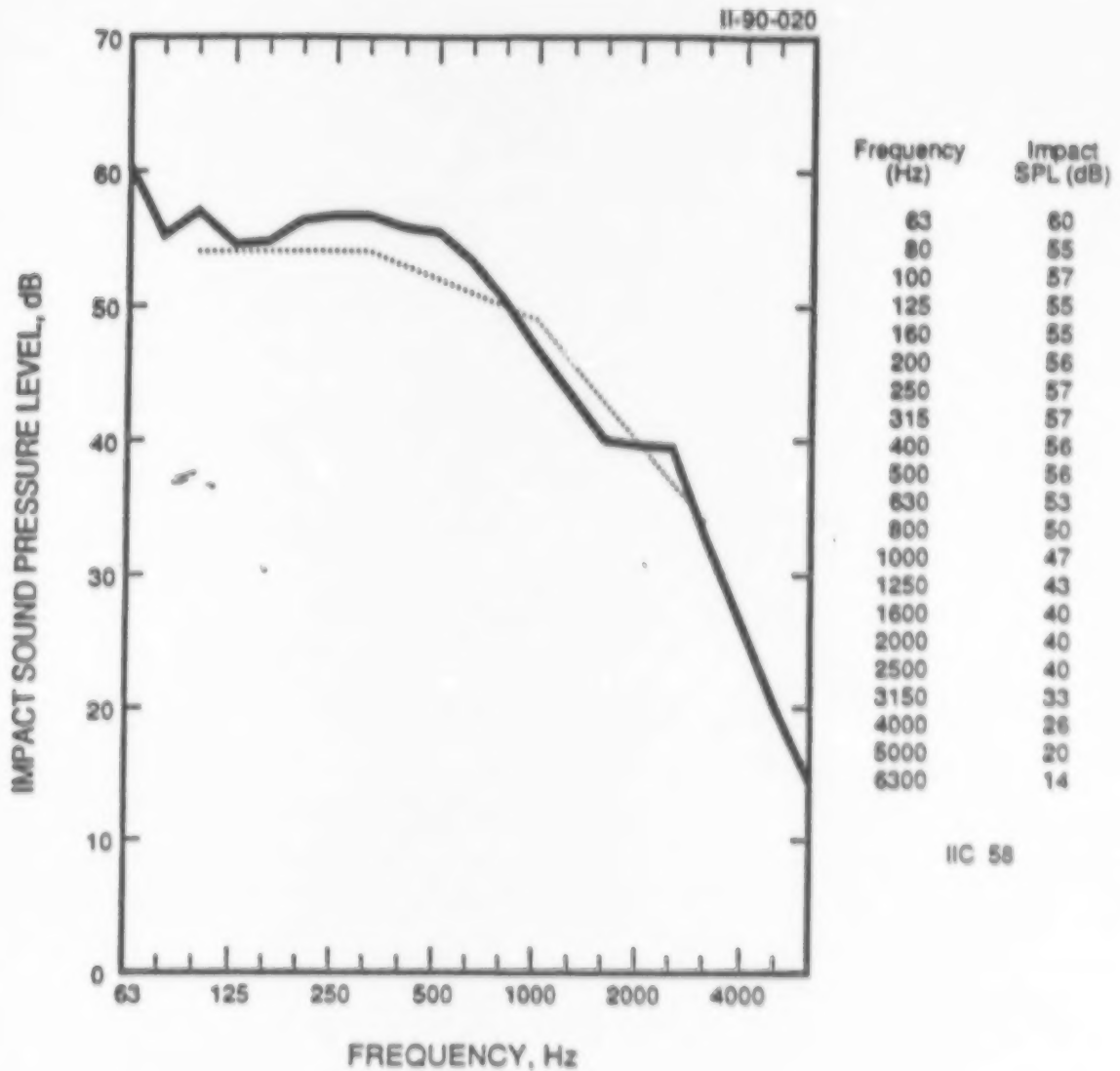
Floor 16: II-90-019

- 16 mm tongue and groove plywood
- 11 mm wood fibre board
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



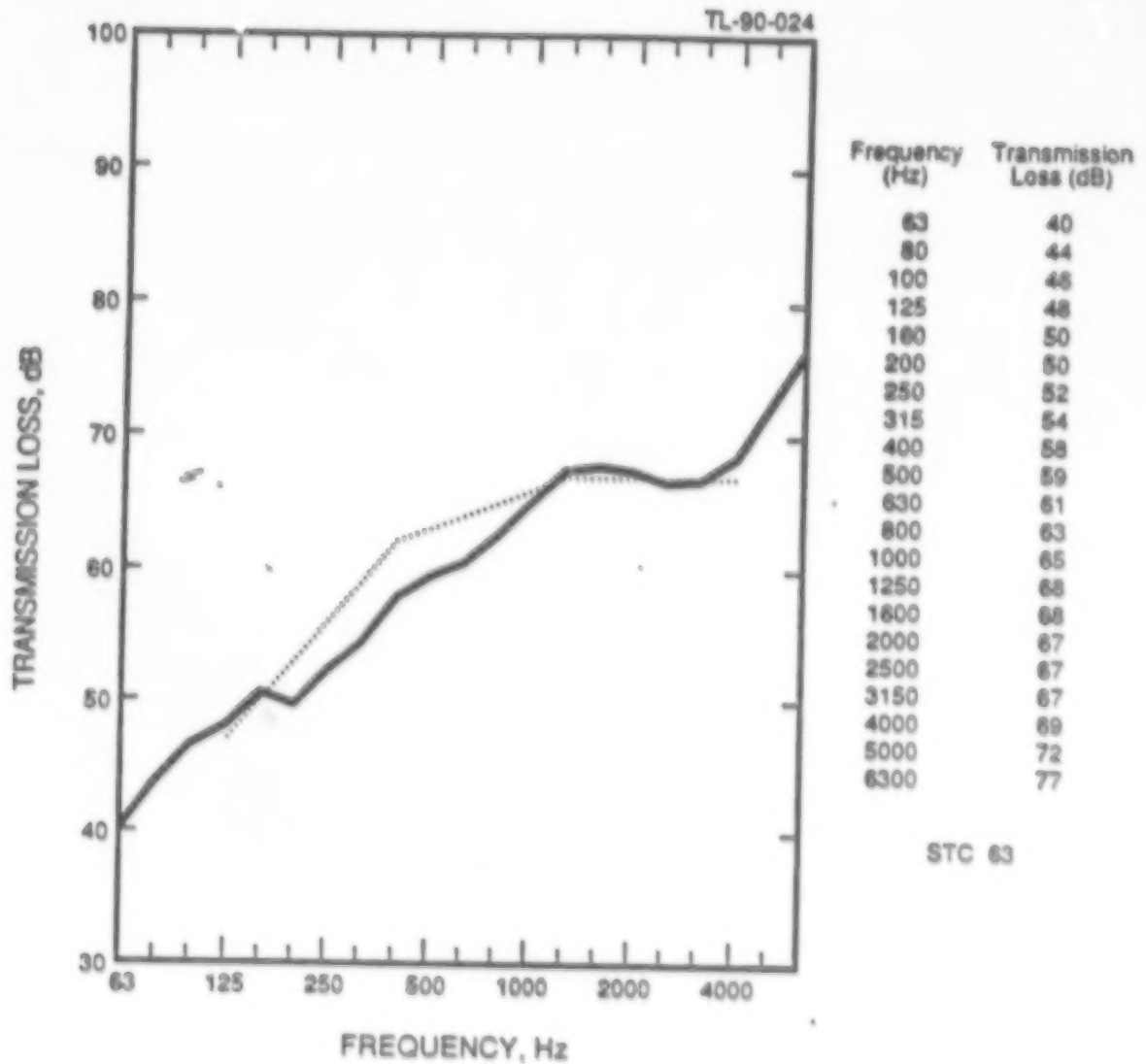
Floor 17: TL-90-023

- 2 layers of 6 mm Wonderboard laminated together
- 2 mm geotextile material, Mirafi
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



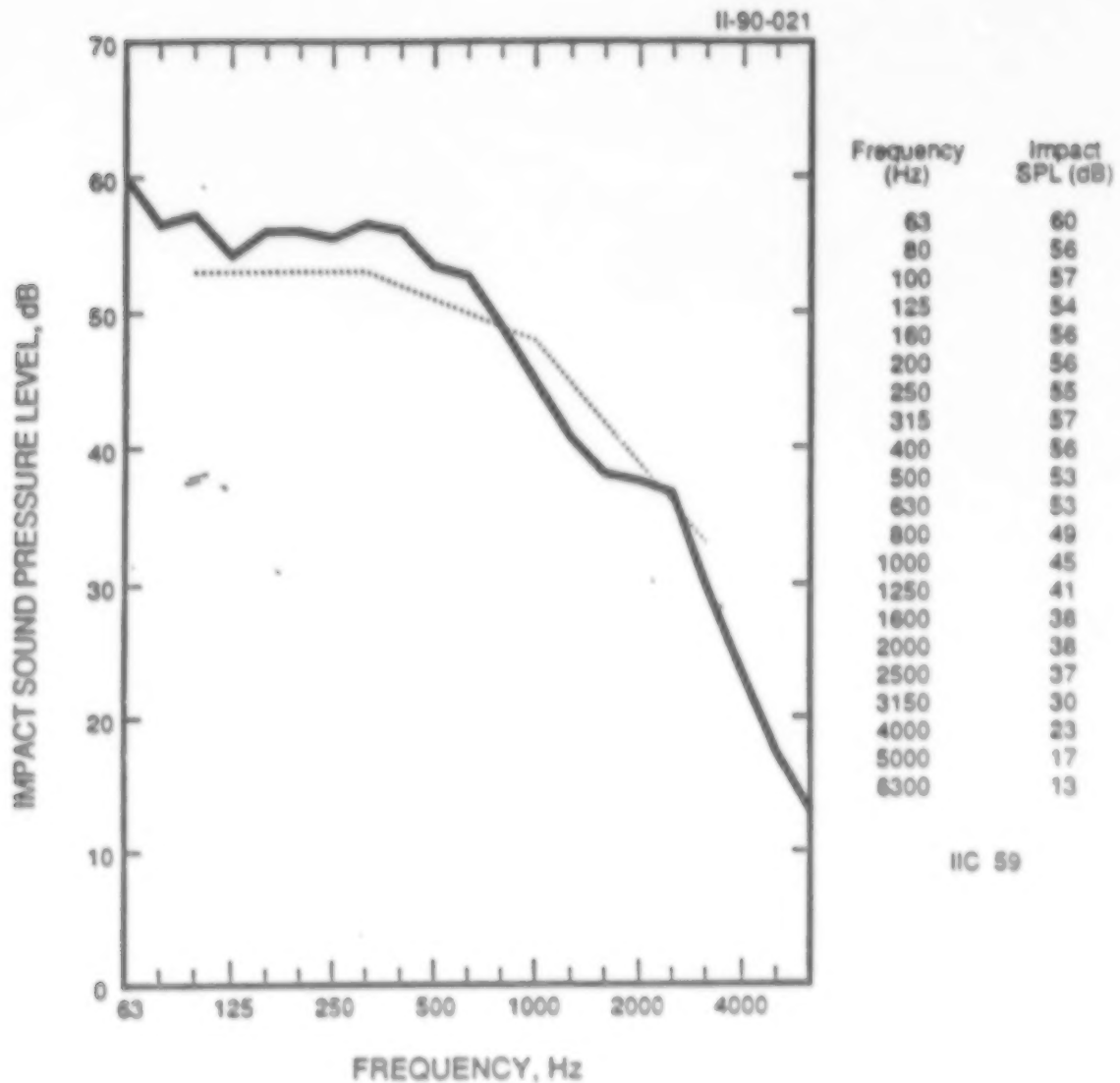
Floor 17: II-90-020

- 2 layers of 6 mm Wonderboard laminated together
- 2 mm geotextile material, Mirafi
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



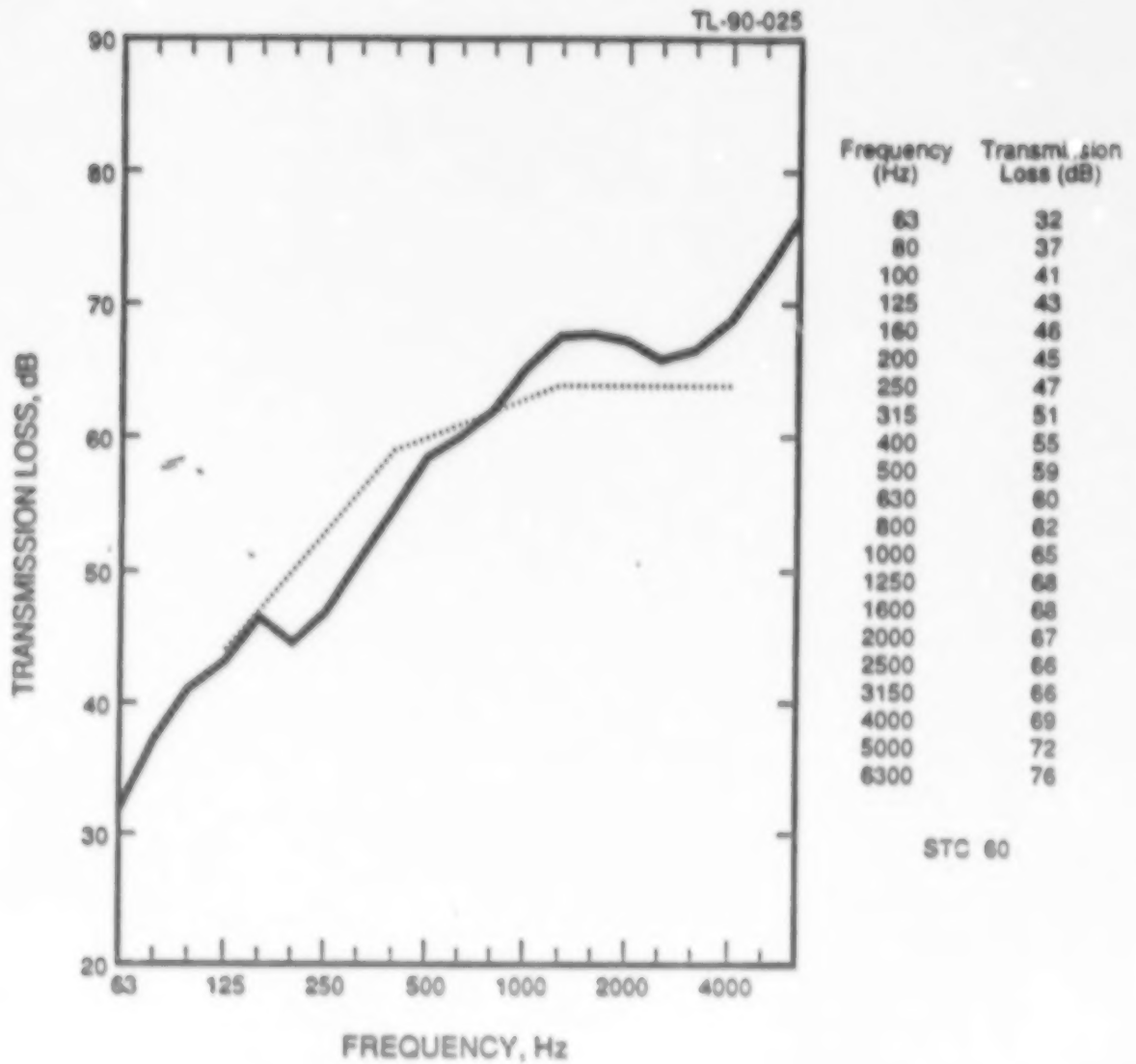
Floor 18: TL-90-024

- 2 layers of 6 mm Wonderboard laminated together
- 6 mm felt underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



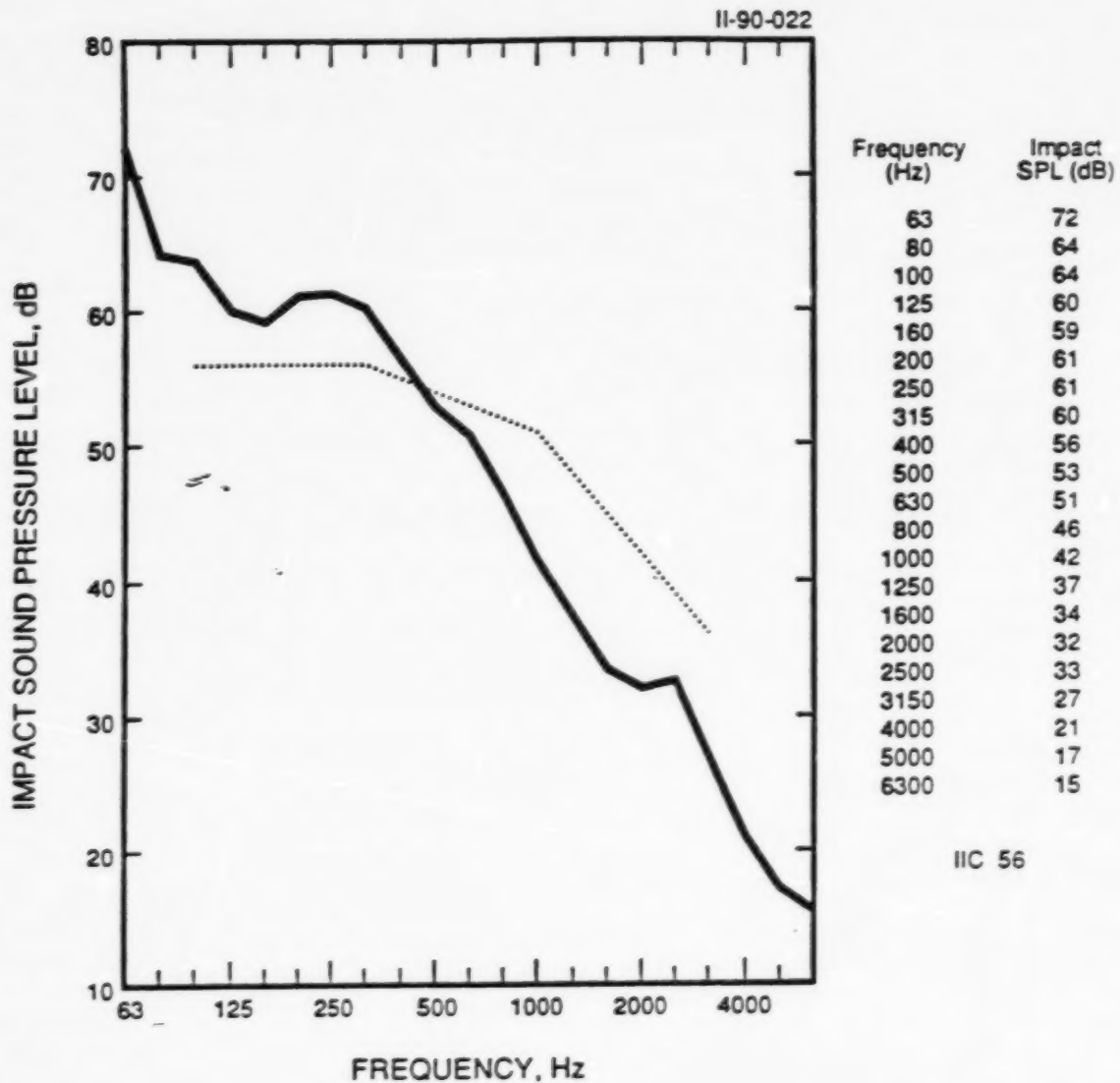
Floor 18: II-90-021

- 2 layers of 6 mm Wonderboard laminated together
- 6 mm felt underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



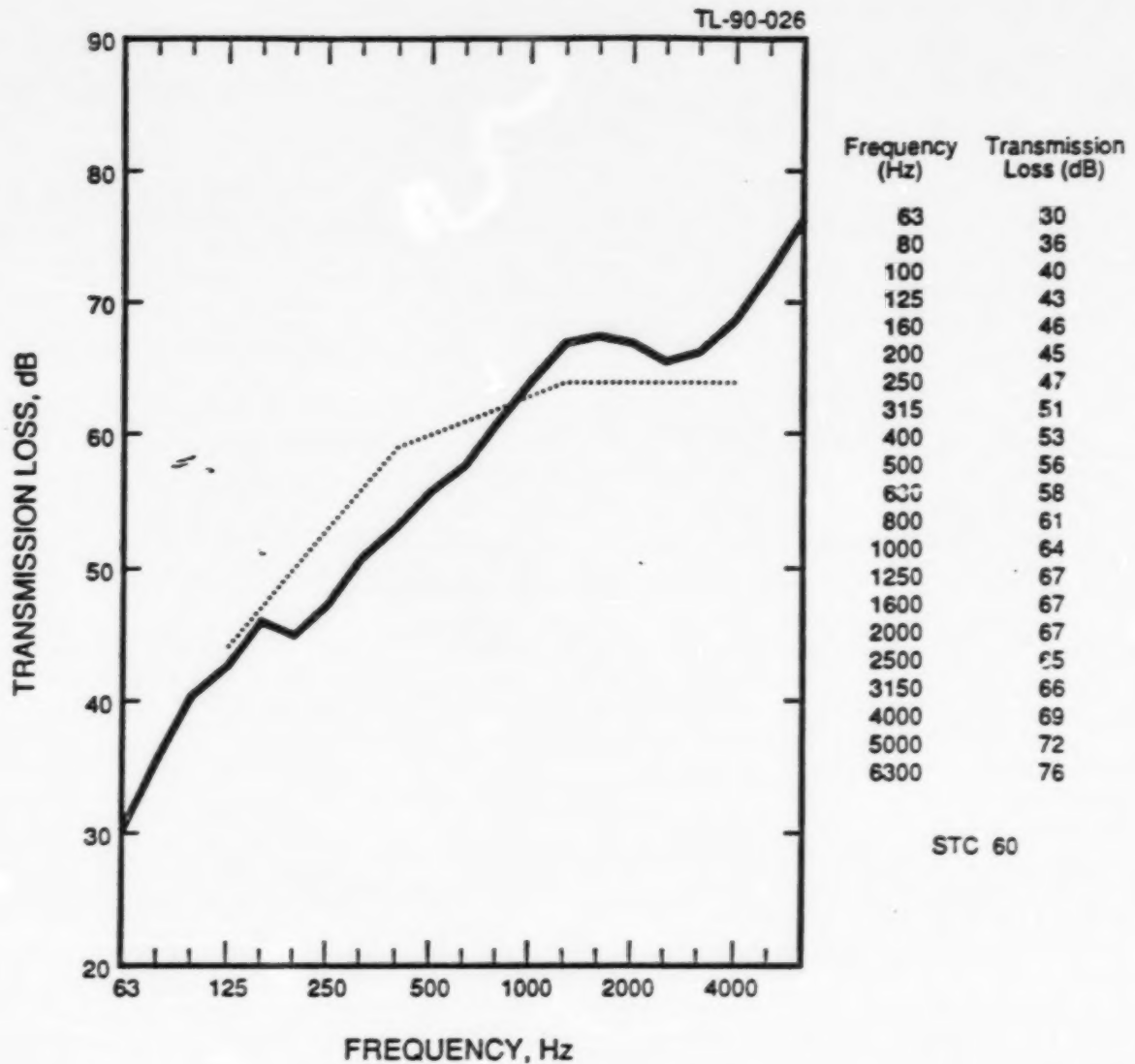
Floor 19: TL-90-025

- 2 layers of 9 mm plywood laminated together
- 6 mm felt underpad
- 18 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



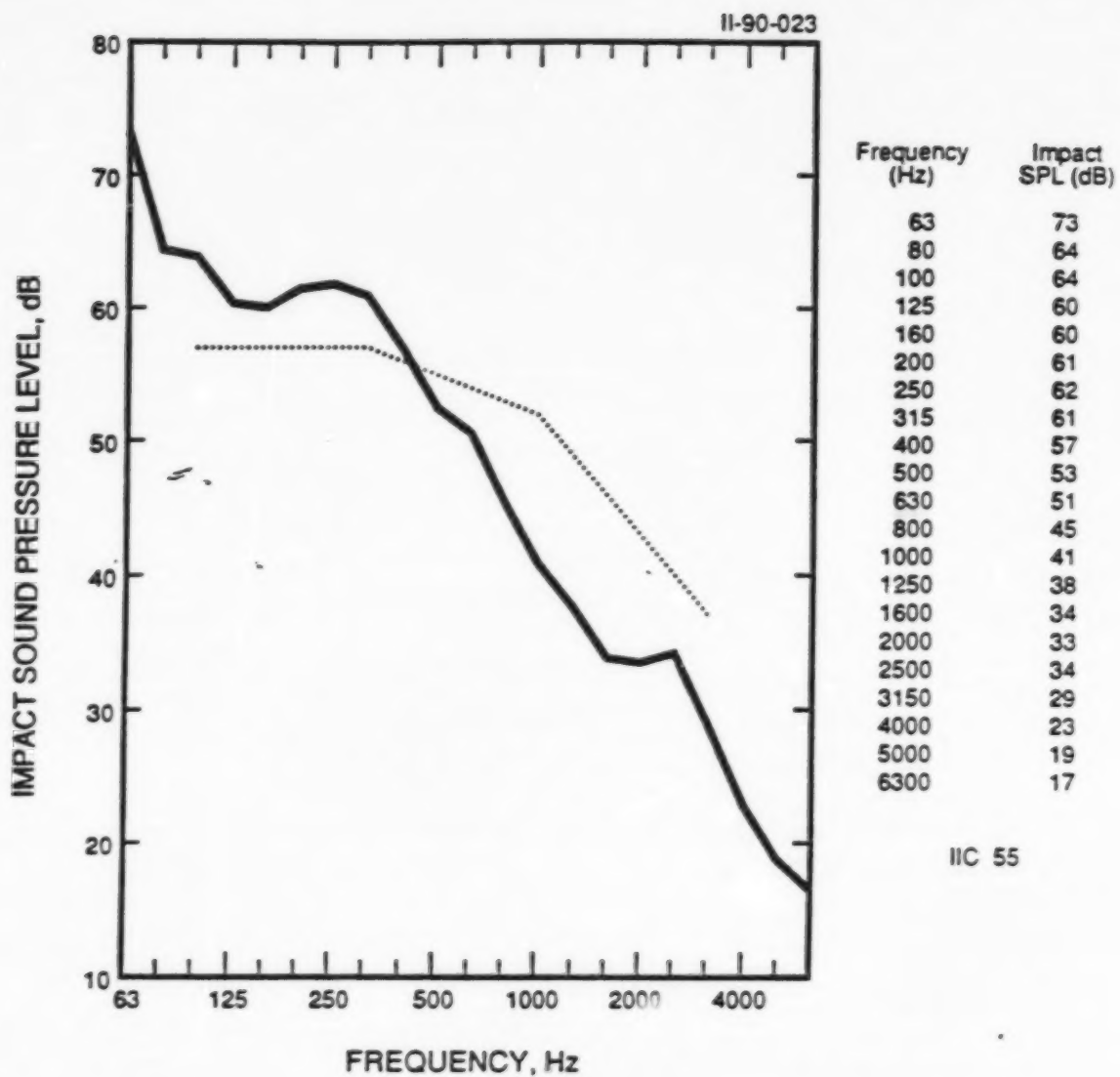
Floor 19: II-90-022

- 2 layers of 9 mm plywood laminated together
- 6 mm felt underpad
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



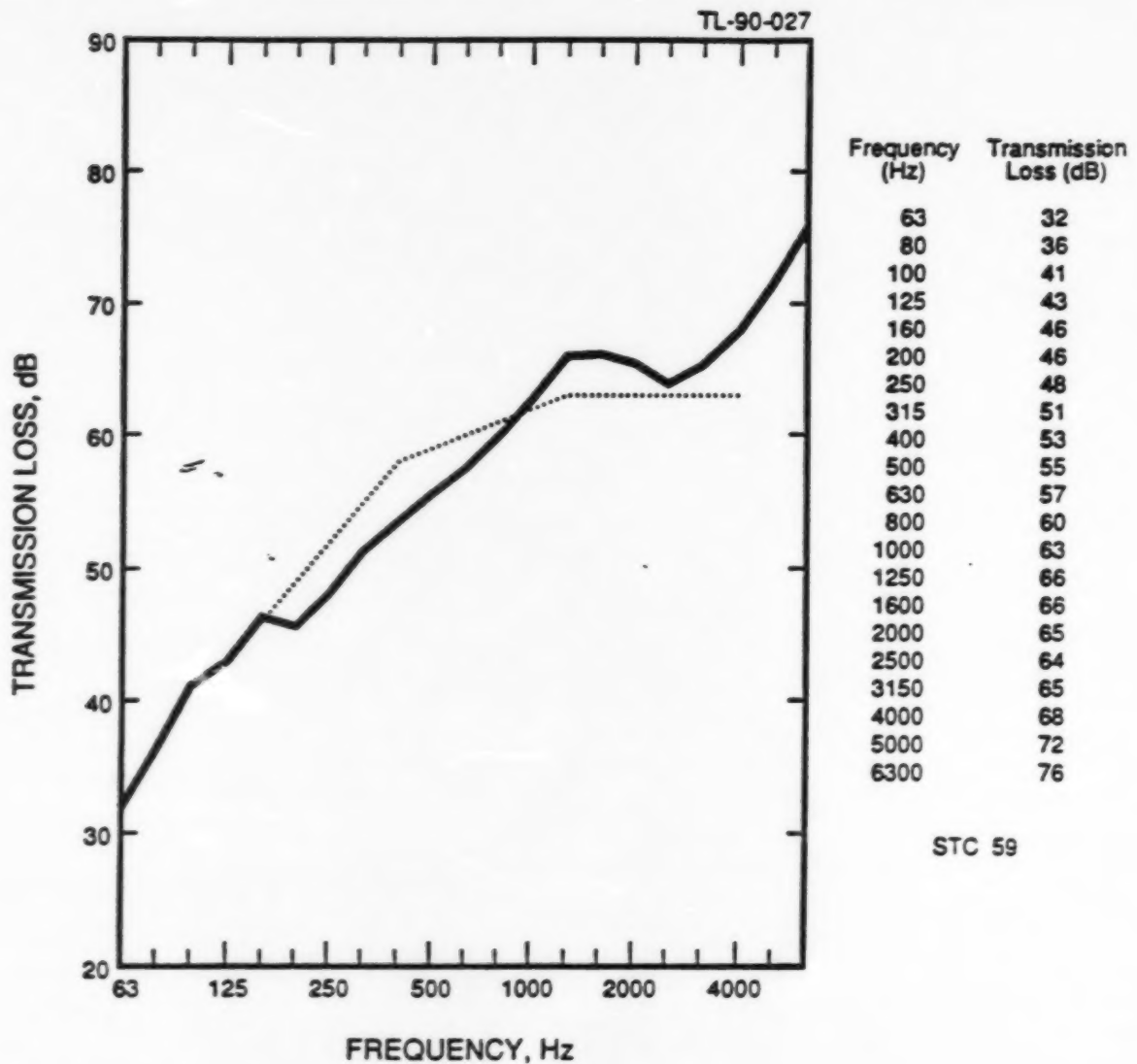
Floor 20: TL-90-026

- 2 layers of 9 mm plywood laminated together
- 2 mm geotextile material, Mirafi
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



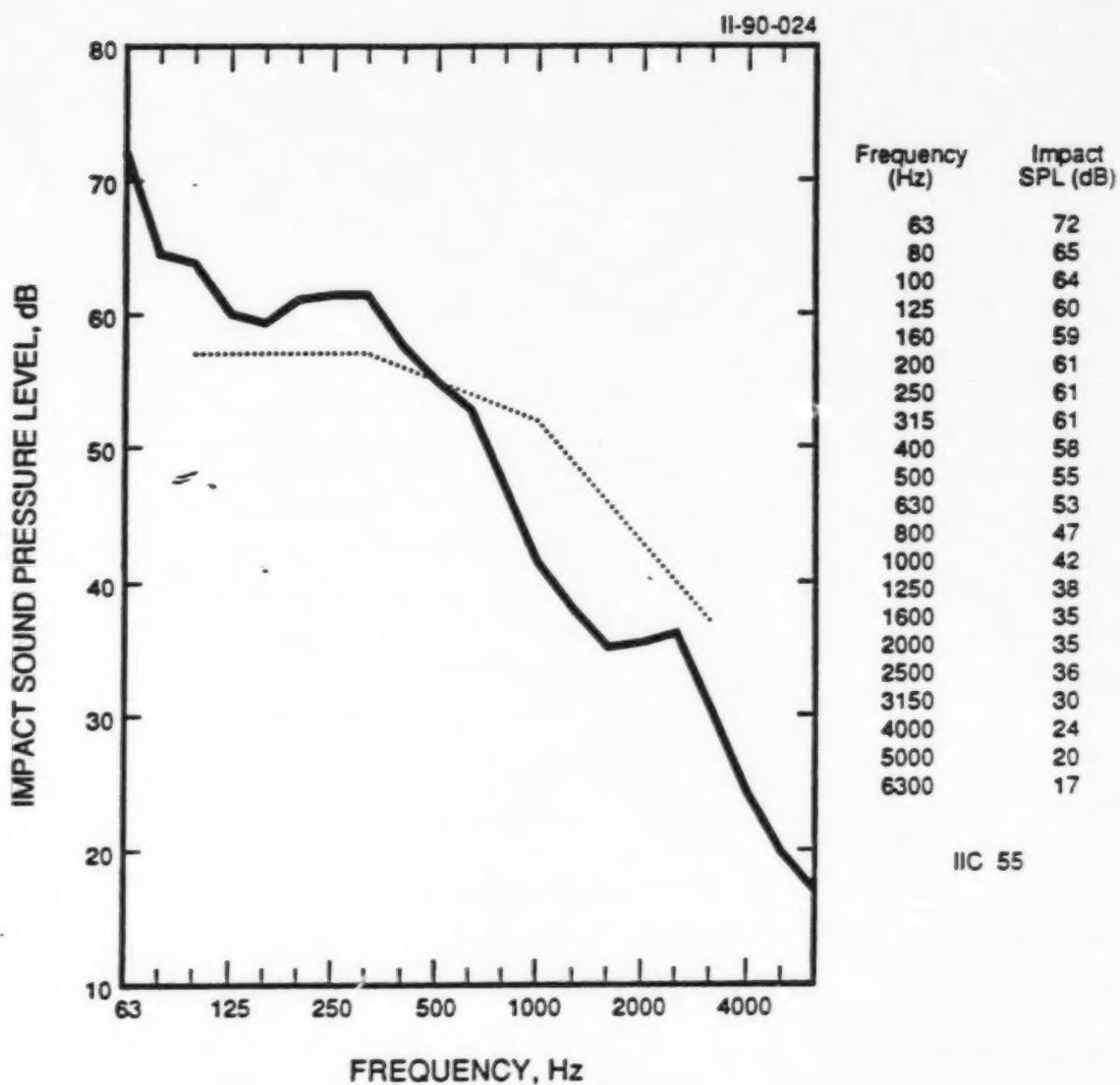
Floor 20: II-90-023

- 2 layers of 9 mm plywood laminated together
- 2 mm geotextile material, Mirafi
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



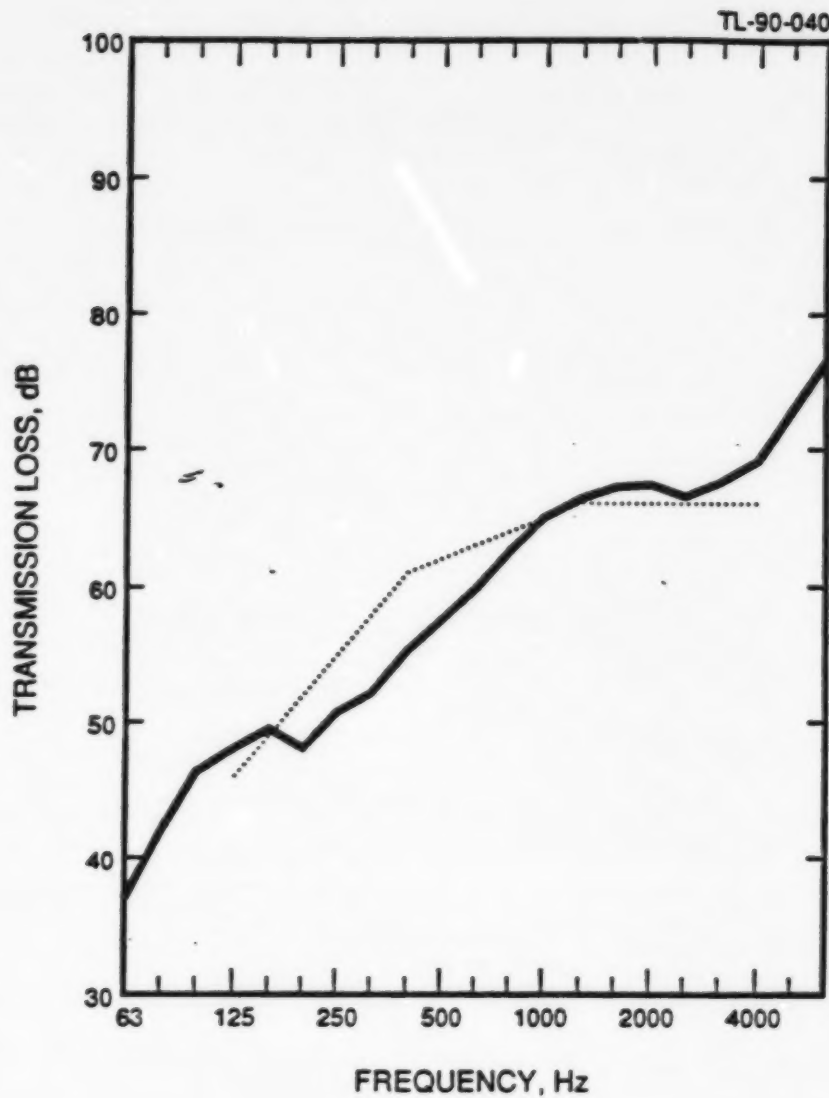
Floor 21: TL-90-027

- 2 layers of 9 mm plywood laminated together
- 3 mm closed cell neoprene foam
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



Floor 21: II-90-024

- 2 layers of 9 mm plywood laminated together
- 3 mm closed cell neoprene foam
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall

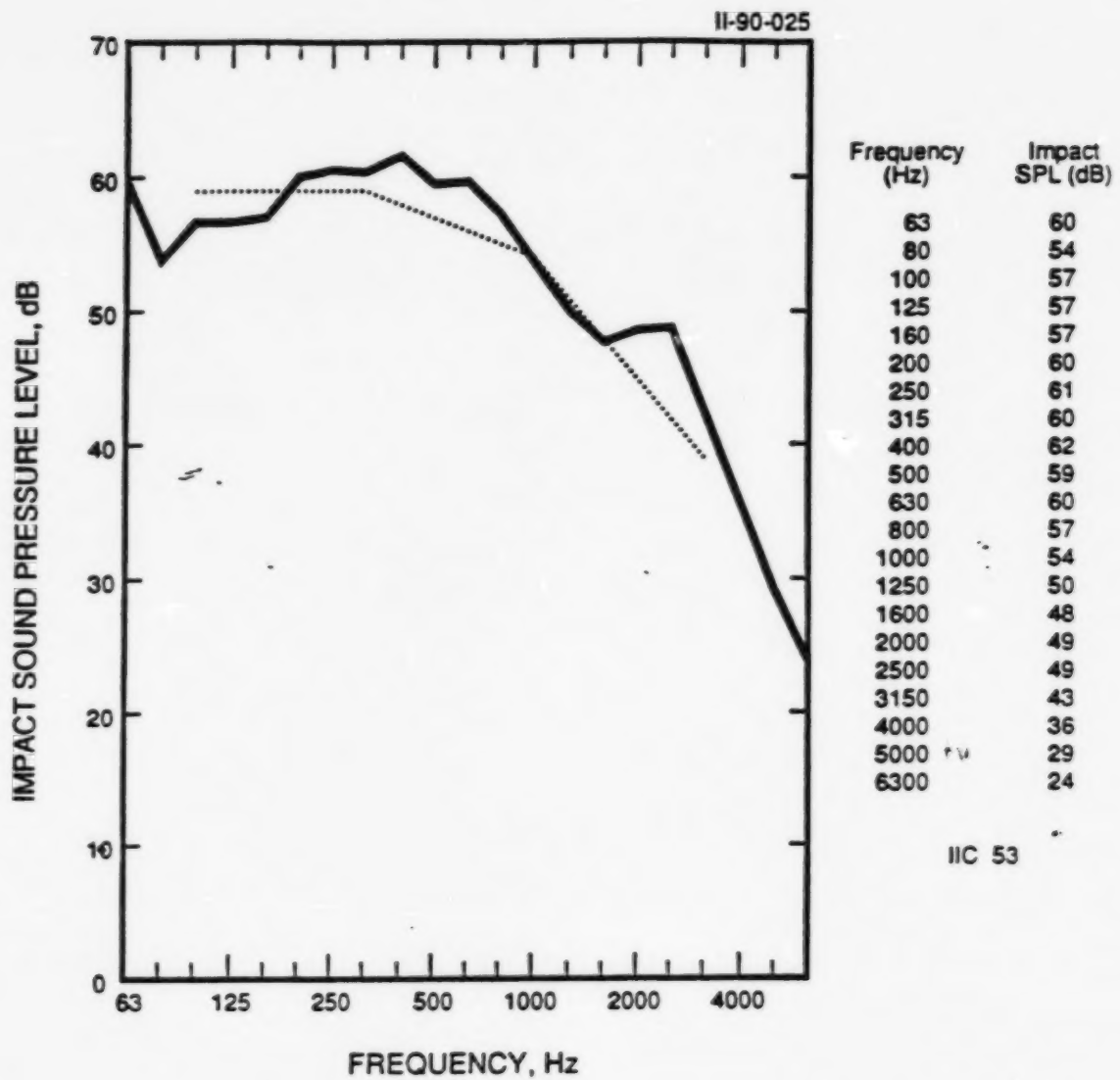


Frequency (Hz)	Transmission Loss (dB)
63	37
80	42
100	46
125	48
160	49
200	48
250	51
315	52
400	55
500	57
630	60
800	63
1000	65
1250	66
1600	67
2000	67
2500	67
3150	68
4000	69
5000	73
6300	77

STC 62

Floor 22: TL-90-040

- 2 layers of 6 mm Wonderboard laminated together and screwed to
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall



Floor 22: II-90-025

- 2 layers of 6 mm Wonderboard laminated together and screwed to
- 16 mm tongue and groove plywood
- 240 mm wood joists
- 3 layers of 90 mm glass fibre batt insulation
- 13 mm resilient metal channels
- 2 layers of 16 mm drywall